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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

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The CHICAGO MEETING AND DINNER OF THE SOCIETY

THE fundamental design of a tractor involves first the size of the tractor, the number of plows it will pull or the drawbar pull For many years the sional session, and concluding in the evening with one of the largest and most successful dinners ever held by the Society—the meeting held at the time of the Chicago Automobile Show brought out information and discussion of the sort that lead every member and guest in attendance to register their highest appreciation of the efforts of those taking part in and arranging the program.

The standards meeting was held under the auspices of the Tractor Division of the Standards Committee of the Society, with Chairman Dent E. Parrett of the division acting as presiding officer.

A number of subjects previously assigned to the division for consideration were discussed in order to give the division the benefit of the combined knowledge of the members at the meeting. Among these may be mentioned the punching of drive-wheel rims, power-belt widths, steel specifications, screws and bolts, spark-plugs, carbureter flanges, and fuel and lubrication pipe fittings.

Chairman Parrett emphasized the importance of the work being done, and requested the presentation of any ideas of service to the division in its future activities. As a result some valuable suggestions were made both as regards the general scope of tractor standardization and the specific subjects under consideration. A complete report of the standards session is published elsewhere.

Tractor Engineering Session

At the afternoon session, with President Kettering in the chair, a meeting was held at which four papers on fundamental tractor engineering subjects were presented. (These appear on other pages of this issue.) George T. Strite discussed the fundamentals of tractor design, analyzing examples of present construction in order to show the future tendencies. H. C. Buffington described what he considered the essentials of a successful tractor engine as gathered from actual experience.

E. R. Greer outlined the general types of tractor transmissions now in use, dealing with such fundamentals as the design of the traction devices, the general method of final drive and others affecting the transmission arrangement.

The paper presented by George Cormack explained the farmers' requirements of tractor service. Mr. Cormack emphasized particularly the necessity for a practical, sane design as one of the best methods of solving the tractor service problem.

The War Dinner, which was held at the Morrison Hotel, was attended by nearly 1200 members and guests. A feature of the dinner was an elaborate musical program, in which the Apollo Musical Club, the Theodore Thomas Orchestra and other artists took part.

The immense amount of detail connected with the arrangements for the dinner was in general charge of David Beecroft, chairman of the Meetings Committee of the Society. He was ably assisted by the Mid-West Section of the Society, of which Charles S. Whitney is chairman, Darwin S. Hatch, secretary; George L. Lavery, treasurer, and by the following members of the Mid-West Section: Burley B. Ayres, in charge of the War Dinner program; F. E. Place, reception; F. W. Parker, Jr., marshal; C. J. P. Lucas, decorations; W. A. Roth, installation, and by Porter E. Stone, badges.

ADDRESSES AT CHICAGO WAR DINNER

The members and guests in attendance at the War Dinner were called to order by Councilor H. L. Horning, who introduced General Lyman W. V. Kennon, commanding officer at Camp Grant, Ill. General Kennon enumerated the factors of importance in carrying on the war, and said that while materials, munitions and food were all important, the most essential factor was the man-power. Councilor Horning discussed the work being done by the Society members, showing that automotive engineering activities embraced practically all the power devices required in war work. He then read a letter from President Wilson thanking the members of the Society for their previous efforts and expressing regret he could not be present. Mr. Horning also read a reply to President Wilson's message, which the meeting unanimously voted should be telegraphed at once. Past-president W. H. Vandervoort was then presented as the toastmaster of the evening. He outlined some of the problems now being encountered by the Navy and War Departments, showed the importance of the work the Society is doing in the solution of these problems, and finally introduced President Kettering as the next speaker.

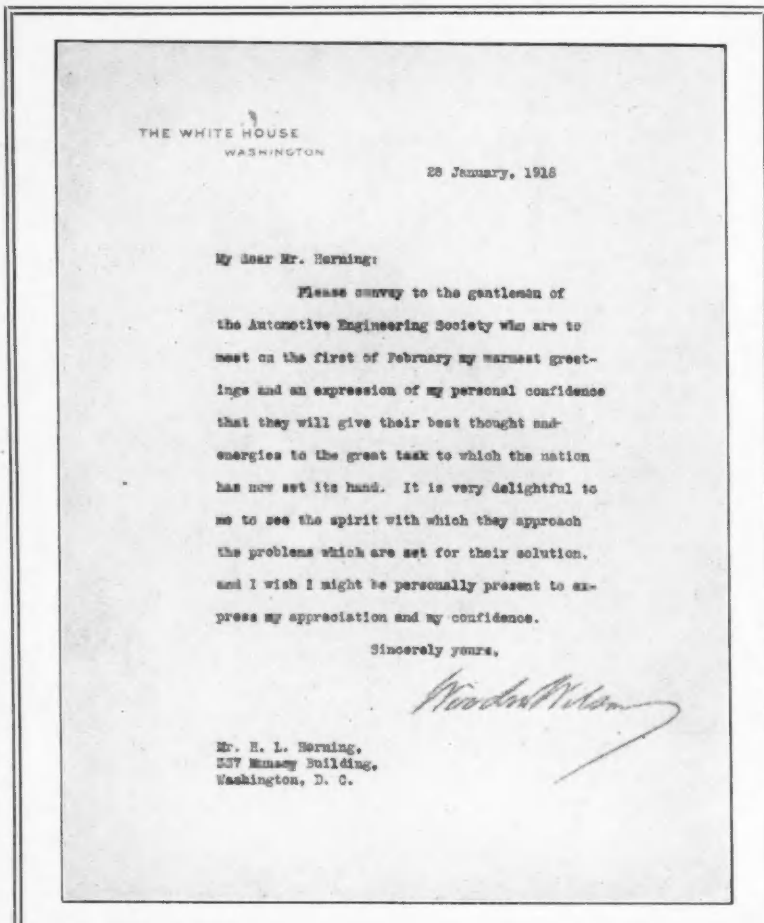
Mr. Kettering dealt with a number of matters of interest to the members of the Society. The fuel problem, he said, required immediate steps for solution in order that the automotive industry might continue its onward progress. Mention was also made of the importance of the tractor to the Nation in solving the fuel problem, of the necessity of applying suitable limits to the engineering work now being done for the Government, and touch-

ing on the satisfactory progress of the aeronautic program in this country.

Toastmaster Vandervoort then read a message from General P. Tozzi, head of the Italian Military Commission in this country, expressing regrets that he could not be present, and stating that a gathering such as the War Dinner, at which the representatives of all the Allies were present, was an immense aid in strengthening international fellowship.

Major William G. Wall, a past vice-president of the Society, and now in the Motor Section of the Ordnance Department, U. S. A., next described the work the Ordnance Department has been doing in securing the necessary guns and munitions for the use of our army abroad. He also touched upon the work being done in building motor trucks, tractors and tanks for the use of the Ordnance Department.

Major L. C. Eckenfelder, representing André Tardieu, French High Commissioner in this country, told the assemblage something of the experiences he had encountered during two years spent in the trenches, and of the work being done by the French in supplying guns to the other members of the forces of Allies in this conflict.



THE WHITE HOUSE
WASHINGTON

28 January, 1918

My dear Mr. Horning:

Please convey to the gentlemen of the Automotive Engineering Society who are to meet on the first of February my warmest greetings and an expression of my personal confidence that they will give their best thought and energies to the great task to which the nation has now set its hand. It is very delightful to me to see the spirit with which they approach the problems which are set for their solution, and I wish I might be personally present to express my appreciation and my confidence.

Sincerely yours,

Woodrow Wilson

Mr. H. L. Horning,
537 Munsey Building,
Washington, D. C.

As a conclusion to the affair, Toastmaster Vandervoort rendered tribute to the work England has done in the war, particularly with her fleet and brave army now in France and her enormously increased manufacturing facilities.

ADDRESS OF COUNCILOR HORNING

IT is a great joy to see gathered here from all the four winds of the earth our allies and our friends and all those who are trying to do everything possible in their power to win this war. I have just read the last paragraph of one of President Wilson's speeches: "To such a task we can dedicate our lives and our fortunes; everything we are and everything that we have, with the pride of those who know that the day has come when America is privileged to spend her blood and her might for the principles that gave her birth and happiness and the place which she has treasured. God blessing her, she can do no other."

When I read that I realized why such a force of men standing for the things that will win the war has come together, and I welcome here in behalf of the Society and the Mid West Section all these men, allies, sailors from the Great Lakes training station, and soldiers of the great new American army from Camp Grant who have stood guard over us all while we have been eating.

I wonder if it is realized that all the great forces which we are about to bring to bear to win the war are represented here. In the automotive forces represented at this meeting are men who have been responsible for the finest aeronautic engine in the world, and for the finest truck, for which England, France and Italy are waiting. They are responsible for the engines that drive the submarine chasers. Members of this Society are responsible for the great merchant fleet which is about to come out and win for us the war by carrying overseas the food that is so necessary. Members of this Society, through the tractor engineers, will supply the thing that is so lacking now, and for which our Allies are crying—food. Members of this Society will furnish motorcycles and the other automotive apparatus, and members of this Society, through the organizations and the plants that they represent, are constructing engines of war that we cannot mention in this meeting.

Day in and day out, in Washington, things are going on that should make us proud to be Americans, and of the preparations that are being made. It is a shame that at this time a cry should come against the fifteen years' progress that has been made in nearly nine months. With all these things so it is particularly gratifying that in the White House should reside a man who is the clearest thinker in all the world today. I have the honor of reading now a letter from our great President, Woodrow Wilson, addressed to the Society of Automotive Engineers.

When this letter was received, the Council of the Society voted that a telegram should be sent, representing the feelings and sentiments of this meeting. This telegram follows:

"HON. JOSEPH E. TUMULTY:

"The Society of Automotive Engineers, meeting in Chicago, February 1, 1918, ask that you present our loyal salutations to the President and inform him that it is our earnest prayer that his health may be preserved and that he may be given the strength to carry on the great burden entrusted to him, that peace and good will may again bless all mankind, and we pledge the skill and all our resources at our command so that that end may be met."

I now have the pleasure of presenting the toastmaster of the evening. He is a past-president of the Society, is doing wonderful work in the war—one of those men

that are silently doing things we very seldom hear of in the papers, but he is putting over the punch that is going to carry us "over there."

ADDRESS OF GENERAL KENNON

IN the army we are limited in expressing some of our views. We are prohibited from talking and from writing on certain subjects, and this applies all the way down from the generals to the privates.

What I want to mention especially are the different methods by which we are going to win the war. Many people think we will win the war by talk. It isn't as simple as that, but the talk does create a sentiment, which, if properly presented to the people, will bring in the spirit and the will to victory. Talk, therefore, has its place.

Frederick the Great is credited with a remark that an army, like a snake, moves on its belly, and it is true as to that today. An army cannot get away from its line of communications. That means the cracker line, the line that feeds the army. That line involves transportation, in which the members of the Society are interested. Some people say food will win the war, but it is not as simple as that.

Then we have said munitions will win the war. They are necessary, but they will not win the war. Some have said that this is a war of materials. We, of course, must have materials of all kinds in a great abundance, but they will not win the war.

Back of all these we must have men. Before the Russian débâcle 36,000,000 men were opposing one another. These men were engaged in winning the war with all these different appliances. They have not won it yet, but they will win it. It means that we must have, to win the war, not only men, but trained men. We have thought of almost everything in this country, but the trained man has been almost neglected.

Professor Sumner, in his book on "What Social Classes Owe to Each Other," defined organized charity. He said that A and B got together and decided what C should do for D, and he called C the forgotten man. It is almost that way with our soldiers. We must have soldiers, and back of the soldiers we must have the people.

Soldiers are likened unto the sharp edge of an axe, for example, a cutting tool that is useless without the weight back of it. This cutting edge is the trained troops, and the people back of them, supplying all of these necessary things, are the weight and body that drives the axe through. That is what we hope and expect from the people.

We must train our young men in order to meet the necessities of the nation in time of war. That is the ideal of our Constitution—the trained militia, not the regular army or regular selected body set apart—but that every one shall be trained. This trained militia embraced every able-bodied man in the country, so that the doctrine of universal suffrage (which some of us are preaching and which I thoroughly believe in) is simply a reversion to the old Constitutional doctrine.

ADDRESS OF MR. VANDERVOORT

I HAVE often said that I am proud of the fact that I am an engineer. I am proud to be able to associate with men of the caliber of those attending this great function. As I look over the past ten or twelve years to the early days of this Society, and think of the way in which it started, when a few loyal patriots came together and contributed several hundreds of dollars apiece in order to get the organization on its feet, then I am truly amazed at the wonderful growth that it has had during these years. How wise that this Society should have been formed in the years gone by in order that we may have developed to that point that we can now become a real living factor in the producing of that work which our government and our allies so sorely need at the present time!

When I think of such men as Howard Coffin, of Major Wall, of Christian Girl, of Howard Marmon and other engineers that stand high in our list, of the work that they have done and the work they are still doing, I feel that we are to be congratulated on having a force at Washington and a force at home in our factories and in our engineering plants to carry on this great work.

We are at war! We entered this war in an unprepared condition. To my mind the greatest political error that could have been committed was that error of not permitting this country to prepare during those three years before we became involved ourselves.

It is all very well for the members of Congress today to criticise those men that are working at Washington, but they should reflect a moment; they should ask themselves the question, "Why are we today asking the engineers, the manufacturers, the people of this country to do in a short space of nine or ten months the work that they should have been given at least three years to do?" It will cost our nation billions of dollars and thousands upon thousands of men to make up for that great—may I say it?—the greatest of all criminal errors that could possibly have been made.

This is no time for criticism. This is a time when we must hold up the President of the United States with our most loyal support. I have no patience with the man that is criticising the Secretary of War or the Secretary of the Navy today. The world hardly knows what those men have done. The very character of the work that they are doing makes it necessary for them to maintain secrecy; it is a military necessity, but I have discussed these things with both the Secretary of the Navy and the Secretary of War, and I thank God that I never found it in my heart to criticize either of them. They are doing a great work, and I feel that we must give them our undivided support.

We must remember that the Navy had an organization and was a going institution. We had our battleships, our submarines, our chasers, our torpedo boats and our destroyers. It was an easier problem for the Navy Department, and as a result it is not receiving the amount of criticism that the War Department is, simply because the Navy could go ahead like a great going business institution and get what it required. The War Department, on the other hand, had an entirely different problem. When we stop to consider what it has done during these nine or ten months we will agree that it has been a marvelous work.

There is a great duty that falls upon every man who is privileged to remain at home, every man who can enjoy his family, enjoy his home, enjoy the comforts of living in this wonderful country of ours. Are we doing all that we can to help those boys on the other side? Are the men that are working with us doing all that they can do? Is it eight hours a day with us? Or is it ten, or is it twelve? What is it with the men on the other side? It is twenty-four hours, it is Sundays, it is holidays. There are no Garfield orders on the other side! When any man says to us that eight hours should constitute a day of labor and then suggests that it should

be seven hours in a time like this, I claim that it is all wrong. The hours of labor are all the hours that we can physically endure.

We are fighting the most highly organized nation in the world—Germany. When the call went out for arms in that country they were ready to move forward almost within an hour. Had it not been for the automobiles and the automobile trucks we do not know what the answer would have been. It was the work of the engineers and of that great man, General Joffre, that saved Paris.

I was much impressed at the time we were raising the second Liberty Loan by the statement put out by the Union League Club of Chicago, the appeal for the American soldier going to the front.

"They say, who have come back from over there, that the troubled earth at night is between the lines carpeted with pain. They say that death rides whistling on every wind and the very mists are charged with awful torments. They say that of all things spent and squandered over there, young human life is held least dear. This is not a pleasing prospect for those of us who still can feel upon our lips the pressure of a mother's good-by kiss. But, please God, our love of life is not so great as love of right.

"In this, the renaissance of our country's valor, we who wage the wage of her assaults make calm acceptance of the hazard. For us the steel-swept trench, the cold, wearisome watch. For you, you for whom we go, you millions safe at home, what for you? We must have food, we must have care, we must have clothing for our bodies and weapons for our hands. We must have, without failure, supplies and equipment in a stream that is constant and never ending. From you our resource and our reliance, from you the heart and hope of that humanity for which we smite and strive, must come these things."

ADDRESS OF PRESIDENT KETTERING

WE are gathered together here to consider some of the great problems that lay before us as a Society. A particular part of the work that we have to do has been discussed today in a session on tractors.

I wonder if any of us has ever stopped to analyze what is the basis of the Society of Automotive Engineers. We read of the historic inventions, of the steam engine, of the steamboat, and of other transportation devices. We recognize what a tremendous importance they have had in our world's history. The Society of Automotive Engineers is the result of something fundamental—the internal-combustion engine. When I say internal-combustion engine I am not unmindful of the wonderful development that is being made also in the steam automobile and tractor, and I am in no wise excluding those motive devices from consideration.

There has never been given to man before such a device as this, because it is the first time in the history of mankind that he has had a small mobile, inanimate power device; that small inanimate power device has made it possible for mankind to do, as he has never done before, the work of sustaining the human race.

We talk of those things that have had to do with the molding of civilization. We talk of the pen and the sword. But the great factor that has caused the wonderful development of all of our civilizing devices has been the use of inanimate power. The city has developed because of its wonderful system of electric distribution. Back of this is a great power unit somewhere in the city, and if that power unit stops the lights go out and the motors stop, but with the internal-combustion engine we carry with us the powerhouse, we move it wherever we please, and we do all of the work.

The Fuel Problem

The internal-combustion engine is to us the most wonderful thing that has ever been given to mankind, and I emphasize that fact because many problems back of that engine must be considered most seriously by this Society. Up to the present time but few of us have asked ourselves what makes the engine run. We drive up to the gasoline filling station and our gasoline tank is filled. How many of us have ever thought where the gasoline came from? The fuel problem is one of the biggest we have today.

How many of us recognize that there is never a thing moved on this earth that is not moved by solar energy? Everything that moves today in power devices is a result of the sun's energy years and years ago. It has been stored up in our coal banks; it has been stored up in our oil supply and in our gas supply. We have written lavishly in the check books that have been drawn on those reserve supplies. For the first time in our history we begin to question whether we have not overdrawn our account. What are we doing today to replenish our fuel supplies? Today questions are asked whether the automotive industries can go ahead or whether we will not have to curtail on account of fuel.

Our automotive industries have been wonderfully prosperous. We have built enormous factories. This problem of fuel has been discussed by them, but no one has given it serious consideration. But if this automotive industry had spent $500,000 or a million dollars a year on the research subject of fuels, today we would not have a fuel problem. Until we awake to the fact that some day our bank account will be exhausted, that we will have to live from year to year on a fuel basis, and that we must run our tractors and our automobiles and our airplanes this winter and next summer on last summer's sunshine, will we ever have a complete comprehension of the problem before us?

The Tractor Industry

The tractor subject is the one important thing before us at this meeting. We are trying to facilitate the agricultural activities of this country. We have had an iron age and a copper age and other kinds of ages, but in the next 75 or 100 years we will have the agricultural age in this country. It is, therefore, of the utmost importance that we study the tractor subject in every detail. It should not be a question in the mind of any manufacturer how many and how poor a tractor he can get out and make some money. It should be an important problem as to how constructively we are building an industry that will extend indefinitely into the future.

The tractor industry of all industries should not be a get-rich-quick industry. It should look well to the future. We have today about 25 million horsepower of animal power in this country. To sustain that 25 million horsepower we cultivate 125 million acres of land, and all of that is the fuel from which we get the horsepower from animal power. That says nothing of the tremendous number of attendants necessary to sustain this. It says nothing of the enormous overhead.

Do we ever think what an absolutely inadequate, inefficient device the horse is from a power standpoint? The number of horsepower-hours that we get from the horse is small. We use him in the summer time, but have to keep him warm all winter. Suppose a tractor had to be kept warm all winter. What should we say of the de-

signer? The whole ability of mankind to do work with that kind of power is dependent upon the nerve energy, so to speak, of the horse. I am positive that we could raise enough fuel on 125 million acres of ground to give three or four times the amount of energy if we could so utilize it.

The Alcohol Situation

The alcohol situation is perhaps the easiest one to consider from a matter of raising fuel. But our wise and non-thinking American people, through the acts of Congress, have placed upon that prospective industry a tax of $1 a gallon because some poor, degenerate individual might drink the stuff and kill himself. I cannot predict that alcohol is an ultimate fuel, but until we get industrial organizations studying the possibility, until we give them a motive to study it, we will never find the ultimate one.

Idealism Versus Commercialism

This automotive industry is a tremendous thing. It is our automobile industry, our motor-truck industry, our motorboat industry, our motorcycle industry, our aeronautic industry. It has developed manufacturing facilities for producing these devices in a high-grade economic way. Outside of our natural resources we have but one great American asset, and that is our American methods of manufacturing. In no other country in the world is the art of producing high-grade interchangeable apparatus with unskilled work a realized fact, and yet we find when we attempt to turn these tremendous industries to the uses of our government that we are handicapped on every side by limits that absolutely tie the hands of our only asset. I am not saying that that is done intentionally at all. It is done through a lack of appreciation of what is necessary. The designing engineers of all the government departments have designed too much from the standpoint of idealism and have forgotten the commercialism and the absolute things that are necessary to get production.

I have seen cases where bayonets were rejected because the blade was 2/1000 of an inch too narrow. What would be the difference if it was stuck through one what the width was? I have seen cases when steel truck wheels were rejected because the hole was 0.0005 in. too large in diameter. Of what use would a truck wheel be if it had to be made that close? We are working too much on idealistic lines, and if this Society could send one message back to Washington that would be more effective than any other one it would be, Study the practical conditions and let us do those things that we know how to do so well.

It makes no difference in the long run whether the truck wheel is 0.0005 in. beyond or under the technical limits if it is sufficiently accurate and sufficiently good to fulfill its functions as a truck wheel. It makes no difference whether the bayonet is a thousandth of an inch too wide or too narrow if it succeeds in doing the work it is intended to do. The limits that should go on any piece of apparatus are the limits within which it makes a good piece of apparatus and not what some high-minded technician thinks they ought to be.

I am not saying this in any wise as a matter of picayunish criticism because that is the farthest from my mind. I have not yet found at Washington a single official who, if these facts were laid before him in a simple, comprehensive way, was not glad to acquiesce and do what could be done, but we have a condition existing in the enormous increase of the departments in Washington that almost tires us out when we try to carry these things back to the fundamental source. We should be mindful that any criticism we make should not have in it one iota of fault finding, but should stand as a fundamental constructive criticism.

The Liberty Engine

We have heard criticisms of the Liberty aviation engine and of the Liberty motor truck. A man said to me the other day, "Isn't it a fact that 50 engineers are trying to decrease the weight of that engine? Isn't it the heaviest aviation engine that's ever been built in this country?" Perhaps it is the heaviest engine that has ever been built in this country, but it ought to be because it is about four times as powerful as any other engine that has ever been built in this country.

The fundamental fact is that it is the lightest engine in existence today of any considerable horsepower when the factor of pounds per horsepower is considered. No other engine in the world today weighing only 875 lb. will deliver 400 horsepower.

We have heard criticisms of why we have not got those 20,000 airplanes across the sea. Until a year ago 150 or 200 airplanes a year were all we required in this country. We could specify the finest spruce in the world, and we could get all we needed for building that number of planes, but when we jump into a tremendous production we must modify specifications and constructions. It has taken time, but airplanes are coming, and they are coming fast. We are sending abroad today—and I am not saying this from my own point of view—airplanes better than any that have ever flown.

A representative of the British government, whose plans we are duplicating today, said: "I didn't believe it was possible to build airplanes on the interchangeable basis. I didn't believe it was possible for any country to build airplanes beautifully finished and soundly constructed without a long schooling of men." We cannot do that in this country. We do it by assembling together groups of specialists and each one does his little trick. People think airplanes cannot be manufactured by interchangeable methods because it has never been done, not because we have not the ability to do it, but because our government never gave any one an order for over 50 of any one kind of airplane.

A Lesson From Germany

We prepared Germany partly for this war in this way: Germany had her military organization. She had her factories for manufacturing arms, and when she got all the arms she needed she started in making ball bearings for the American automotive industry, and we kept her people employed. When they wanted to go to war they quit making ball bearings for us and went to making guns. We could have done the same thing if we could have gone to Congress two or three years ago and said, "Why don't you let the manufacturers build tools to make machine guns and do those things necessary to produce munitions of war and have them ready? We want to spend a couple of billions of dollars."

I rode on the train soon after the war had started with a paint salesman who sold water colors for schools. He said: "I don't know what we are going to do. We can't get any more paint brushes." I said: "What is the trouble?"

"Those have all come from Germany and we can't get any more of them. We can't get those little camel's hair brushes."

"Who said they were camel's hair brushes?"

"That's what we buy them for. We don't know where to get that kind of hair."

"Well, now, I will tell you what I'd do if I were you. I'd send a man up to Chicago around the stockyards and see if they can't tell you something about that." So they sent an expert to the stockyards and he said: "Have you fellows ever shipped any considerable quantity of hair abroad?"

"Yes, we have always shipped all the hair that came out of the inside of a cow's ear to Germany to make paint brushes out of." (Laughter.)

But we have always felt proud of an imported brush. Always! Whenever we get to feeling proud of a thing that is made in America and quit this idea of importing things then we will commence some real fundamental preparation for war.

They say we cannot make fine aircraft engines here because we have not the material, and yet the facts are that we are shipping and have been shipping to the Allies on the other side practically all of their crankshafts. What we need to do is to analyze our industries, to find out what they can do and whenever this war is over let us tell the government what we want to make of the same munitions we have been making and lay those tools away in some place and keep them.

We should educate our industries how to do this special thing and that special thing, and if this war does nothing else for us, it will make us appreciate what the relationship of industry to war really is and what it is necessary to do in order to have that industry instantly available. If we can get some of those ideas established we can get a great deal of good from the war, and certainly no sacrifice as great as the one we are making now should be made without good comes from it.

The way is cementing together industries that before were more or less jealously competitive. This organization is one of the greatest organizations I have ever known of any industry for the reason that the automotive industry is freer from jealousies, is more cooperative than any other industrial organization on earth. I belong to four or five national societies and certainly the attitude in this organization is pleasingly different.

TELEGRAM FROM GENERAL TOZZI

"IT gave me great pleasure to accept, some time ago, the invitation to be present and to speak at the War dinner of the Society of Automotive Engineers. I was deterred by an unexpected pressure of business which, closing down at both ends upon the period of time I had reserved for the journey, increased immensely the difficulties of the undertaking. I find it, therefore, utterly impossible to be present. I cannot adequately express my regret for it is from just such gatherings as this that international fellowship derives its strength. The significance of a meeting in which so many representatives of various parts of your vast country participate would surely have been emphasized by the presence of a representative, however unworthy, of your ally, Italy. I hope at least that the short address which I hastened to send will convey a message of inter-allied brotherhood. The technical leaders of America, by coming to Chicago from East and West give evidence that the twain have met. May they be made to realize that even higher barriers have fallen and that the hearts of their Italian allies beat as one with their own at this tragic moment when all lovers of freedom stand together against the upholders of tyranny."

(Unfortunately, the address referred to above was delayed in the mails, and could not, therefore, be read at the dinner. It has since been received, and appears below.)

ADDRESS OF GENERAL TOZZI

SINCE my acceptance of the invitation with which the Society of Automotive Engineers has honored me, my mind has been dwelling with intentness upon the subject of the endless changes, scientific as well as moral, which have been brought upon us by this war.

Nothing could seem more absurd than to look for benefits to the race in a war—as absurd, indeed, as the proportions of this war are gigantic. Let this premise save me, an old soldier, from being suspected of the wish to idealize what amounts substantially to a calamity to the human race. Nevertheless, this huge disaster has advantages which, though microscopic as compared to its tragedy, are still perceptible, and which it would be an error not to use and profit by. Let us set aside all social questions, such as the sympathetic approach to one another of the different civilizations of our allied lands, and their mutual growth in interest and respect. Considering, as befits the nature of this gathering, only the technical and scientific side of the question, we cannot fail to admire the cementing of technical industrial activities; their collective development, and their adaptation to new phases of work, and utilization of new economic fields. It is marvelous to observe the recruiting of industries in the European countries at war under the more or less direct supervision of their various governments. France, with grandeur equal to her proverbial élan; England, with her sturdy and indomitable precision; Italy, with an unprecedented efficiency—these all exhibit a wonderful example of industrial union, of collective transformation, of harmony of purpose. Of this harmony, great America has in recent times given amazing proofs, in the coordination of her vast resources, mineral and industrial, whose exponents, from one end to the other of this great territory, respond with fraternal enthusiasm to Columbia's call.

From this union of internal activities in the several nations, we turn to industrial harmony between them; a harmony of which this vast land, inexhaustible in her resources, forms the pivot on which the entire system revolves. There has come, therefore, a widening of technical knowledge, an unexampled scientific development, a steady, surging progress, whose course is today directed toward the instruments of war, and tomorrow will be carried into the domestic field, and adapted to every need in the lives of mankind. It is obvious that both the speedy development of all things produced by human inventiveness, and the great harmonizing of methods inter-industrial and international, which are among the undeniable results of the violence of war, could not have been reached after a century of slow evolution in time of peace.

Passing from a general view to the specialized field of which this imposing and learned gathering in Chicago is an evidence, it behooves me to record the progress of mechanical, as contrasted with animal, traction in modern war; the great importance, the immense development of all forms of the motor car, whether used as a means

CHICAGO WAR DINNER OF THE SOCIETY OF AUTOMOTIVE ENGINEERS, HELD AT THE MORRISON HOTEL, FEB
IN DIFFERENT PARTS OF THE BALCONY. MEMBERS AND GUE

Patriotic Music Supplied by an Orchestra, a Large Pipe Organ and Four Grand Pianos Shown
Number of Over Twelve Hundred Were in Attendance

of rapid transportation of troops, for the purpose of carrying guns, or as a speedy weapon of combat. As long as 5 years ago, in the Libyan war, in which it was my privilege to take part, Italy saw the prodigies of the automobile service, when the great machines, plowing through the burning sands, carried speedily to their posts soldiers and supplies. At the outbreak of this war, it became my duty to experiment in the traction of large-caliber guns forming complete batteries, which were rapidly transferred from one point to another along the great arteries leading to the front. These batteries could bring to bear their powers of destruction on points attacked or threatened by the enemy, substituting for the scarcity of artillery units the rapid grouping of those already existing.

Armored Automobiles

I must also mention here, since it dates from the beginning of the present war, the entrance into action of armored automobiles, functioning as anti-aerial batteries. With these also it was my good fortune to experiment on the Roman fields, against enemy airplanes.

It is not necessary to dwell upon the terrifying new war weapon known as the tank. In common with the before-mentioned war weapons, it belongs in the great, new and unique realm of many sided scientific appliances which, in the days after the war, will accomplish a now inconceivable progress in the science of peace. In Italy, the great name of Fiat—in America the great name of Ford—will win new laurels when men beat their swords into plowshares.

Long before the present war, Italy, who had already reached uphoped-for results in the automobile industry, comprehended, in common with her sister nations, the enormous importance of aviation in modern wars, and she has continued to improve her already up-to-date types as this war has progressed. On the one hand she has developed and improved the reconnoitering machines which are the eyes of the army; on the other she has strained every nerve to perfect the bombing machines, and especially those for night bombing. It may be hoped that in the future, with the powerful aid of the great aerial fleet of America, these machines will be a most powerful element in the solution of battles.

Italy, France, England and America, united by the sacred bonds of civilization, and human happiness, will emphasize more and more the importance of these powerful aerial weapons, and their ability to strike the enemy rearguards, the railroad centers, the warehouses, the munitions works, and *never* old men, women, children, and the wounded in hospitals. Indeed the courageous French and English have already been able to shell the great industrial centres of Essen and Munich. A telling symptomatic experience was that of the daring French aviator who left one morning the French lines in Alsace, avenged at noon, by the accurate and terrifying bombing of Munich, the carnage of Padua (where enemy airships had attacked a place of refuge for the civilian population, killing over 100 women and children), and landed the same night in Venice, beloved among cities—in Venice, where he was soon to receive, with ceremonies worthy of the occasion, the Italian medal for military valor; in Venice, which he left soon after for the crowning glory in the career of a soldier, death in the performance of duty.

At present, Italy with her Caproni machines and her Fiat engines has powerful and practical airships. And now the necessities of warfare have prompted her to establish along the peninsula fixed aerial routes, along which, with the regularity of a railroad service, there is carried on daily airship transportation from Turin and from Milan to our front, a journey of about 300 miles. We have also instituted regular air mail service between Rome and the Island of Sardinia, and between Naples and Palermo, in order to counteract the effect of the diminution of steamship service. All these routes are operated with wonderful regularity, and give a vivid idea of the possible utilization of aerial routes for quick communication between nations. These are actual, if at present only sporadic, forerunners of the civilization of tomorrow.

Standardization in Italian Industry

Passing now from the field of the air machines to that of the elements of which they consist, and which are responsible for their resistance, it gives me pleasure to remark that our Italian industries place great importance upon standardized specifications. It is my opinion that to unify specifications by means of standardization, will not only be a *sine qua non* requirement for better production, but it will also be one chapter in the story of inter-allied unification of ways and means, with regard to purchases and supplies. The union of America's productiveness and inventiveness with the proved results of the military experience of her Allies, will lead us to avoid the fatiguing and uncertain work of attempts, tests and unnecessary mistakes. We shall thus obtain vast results with the speed imposed upon us by conditions of the present war. American technology, long accustomed to audacious methods, will be increasingly able to solve a problem which is of vast importance to us at present; I mean the adoption of new systems of construction allowing economy in the employment of materials whose production is scant, and inferior to our constant and ever-increasing need.

Time limitations must not prevent me from referring in this connection to the daring and ability demonstrated in repairing and putting into service again no less than 100 steamships damaged by the Germans, by means of the unprecedented use of solder actually incorporated into enormous and complicated parts of machinery.

It therefore remains to me only to extend thanks for the honor done me in inviting me to address the Society, an honor which I accept in the name of Italy, who has clasped with fervent joy the hand of America, and who is profoundly happy today to see America's sons standing shoulder to shoulder with her own in this gigantic struggle for civilization and liberty.

ADDRESS OF MAJOR WALL

I WISH to talk not as a soldier but as an engineer and business man, who for the last nine months has been living with some of the problems confronting the Ordnance Department. I am not here to defend the Ordnance Department. It needs no defense before any one who knows the true conditions, and certainly not to engineers and manufacturers who can comprehend the immensity of the task it has undertaken.

It is of record that in spite of the repeated requests by the Chief of Ordnance, Major-Gen. Wm. Crozier, for larger appropriations, the appropriations by Congress for ordnance, and especially field guns, for ten or twelve years before war was declared by the United States, were wholly inadequate, and, in fact, now seem pitifully small.

No sooner had the proper appropriation been made, a couple of months after war was declared, than the Ordnance Department plunged into an engineering and purchasing program the equal of which has never before been known, namely, to furnish the necessary guns, ammunition and equipment within 18 months for three million men; all this to be produced without interfering with the many factories in this country making material for the Allies.

The department was faced with some great engineering problems, as ordnance is of little value unless it is equal to or better than that of the enemy. Also it was advisable to make *some* of our material interchangeable with that of the French. The reasons for this are most obvious, and among them was knowledge that this would prevent a great deal of confusion on the battle front. On account of adapting the caliber of the French guns to make our ammunition interchangeable with theirs —such as the 75-mm., corresponding to the 3-in., and the 155-mm. howitzer, corresponding to the 6-in.—there was necessarily a slight delay in starting the manufacture both of the guns and the ammunition, but even with that, before the first of August, last year, nearly eight million rounds of 75-mm. high explosive and shrapnel shells and one and a half million rounds of 155-mm. shells, besides a large quantity of larger sizes, like the 8-in., had been contracted for and were being manufactured. The number now in course of manufacture is enormous. The greatest problem has been to get the guns and howitzers, especially the large ones. It takes from nine months to a year to make a large gun, so that we cannot go up to a manufacturer's door and knock and say, "I want a cannon," and have him hand us one.

The work on these guns is slow, as it necessarily has to be extremely accurate. What with the forging, turning, boring and rifling, large space and special machine tools are required. Some of these machines have had to be built since war was declared, but with all that eight large plants are now making forgings for these guns, and about that many machine shops are doing the machine work, besides the United States arsenals, which have been considerably enlarged, so that by next August we should have more than 3000 new cannon—that is, guns and howitzers, some of them of the larger sizes—in addition to those purchased abroad. After that the production will be even more rapid, as other plants are being equipped to take up this work. Thousands of Enfield rifles and large numbers of machine guns have been ordered and are now being manufactured and supplied, while the arsenals have greatly increased the production of Springfield rifles, which rifle is acknowledged to be the best made.

A new proving ground has been established at Aberdeen, Md., for proving the new guns. Schools of instruction have been established. In fact, the Carriage Division has had a Motor School with branches in three different towns, besides the Rock Island Arsenal, for the last six months. These schools have officers' quarters and also barracks for the enlisted personnel, and give a course ranging from two to three months in the construction and repair of trucks, guns and tractors. These schools have an excellent foundation to work on, as the ordnance officers and enlisted personnel are mostly all motor men or gun experts.

Ordnance Motor Equipment

When war was declared it was decided to motorize certain of the gun batteries. Later this decision was extended to cover all but one size of gun, and now some of this size are motorized. By motorizing a battery is meant replacing the horses with tractors or trucks. It was found advisable to do this on account of the necessity of rapid transit and on account of the caliber of the guns used for field service having been greatly increased. They had become too heavy for horses to draw.

This motorization introduced a large number of new problems which had to be dealt with, most of which have now been satisfactorily solved. On account of the work the ordnance truck has to do—towing guns and hauling ammunition up to the front lines—sometimes over almost impassable terrain, it was found necessary to use a type of truck driving on all four wheels; so that two makes were adopted, one a 2-ton and the other a 3-ton, which were then being produced by their respective factories. It was thought to be poor policy on account of the limited time available to design a standard four-wheel-drive truck, which might have been better, but would have taken more time to produce. Both of the two existing makes had been tried out on the Mexican Border the previous year.

These two makes of chassis, with the addition of one size of lighter truck, are now being produced by ten large factories with the assistance of about three hundred other factories making bodies and parts for them. These chassis are equipped with different kinds of bodies, most of them with an all-steel ammunition body which is of the proper size to carry in their original packing boxes ten different sizes of ammunition, ranging from one million rounds of rifle cartridges to five rounds of our large 9.5 howitzer shells. In this large size the powder and shells are separate. About a thousand of these chassis are being equipped with machine-shop bodies, regular traveling machine shops with lathes, drills, presses, grinders, electric drills, and other tools for repairing guns in the field, besides an engine and generator. A large number are furnished with equipment repair bodies for repairing harness, clothing, machine guns, and small arms, and have sewing machines and other tools on them for doing the work. Also some are provided with power winches.

Several other types of bodies are also mounted on these chassis for such uses as apparatus for fire control, gasoline tanks, telephones, artillery supply, machine guns, and reconnaissance. Some trucks have the guns for anti-

aircraft work mounted on them so that they can shoot at almost any angle and make a quick run to any place they are required.

A number of different trailers have been designed to be hauled behind trucks, some carrying anti-aircraft guns, others carrying field guns and some large 10-ton trailers, which are used to transport the tractors or tanks rapidly from one place to another. Some of these are also equipped with heavy cranes for mounting guns or lifting wrecked vehicles.

A mobile repair shop consisting of twelve trucks, three machine shops, three equipment repair trucks, and six trucks for supplies is attached to each division. These do their work extremely close to the front.

For every six divisions constituting an army corps there is a corps repair shop with large machine tools on trailers, each trailer having one large tool on it like a lathe or a drill press and one with a large stationary engine and generator; these are semi-permanent but can follow the army and will be of great value when our army advances rapidly into Germany.

Large permanent base repair shops have been established in France which cover more than two square miles of ground. These are equipped to repair the heaviest artillery, besides trucks and tractors.

A number of other types of motor vehicles have been designed, each one for its especial use.

The factories working on these trucks and trailers have been making shipments for the last five months, and it is expected that within the next sixty days there will be a steady flow of about two thousand vehicles a week to our armies in the field.

Military tractors of the track-laying type have been developed for pulling the heavy guns. Nearly nine thousand are in course of construction at several different factories. These are of different sizes ranging from 120 hp. to those with only about 30-hp. rating. They have been developed to such an extent that there is little they will not do in the way of surmounting obstacles, steep grades and heavy going. This is due in part to their being of the track-laying type, and although they weigh, in the larger sizes, nearly eighteen tons, the pressure per square inch on the ground is only about that of a man's foot when walking so they do not sink in like a truck or other wheeled vehicle. Some of these tractors are being armored to protect the engine and machinery.

I wish it were permissible for me to say something about the tanks that have been designed and are being constructed. I can say, however, that if the factories making them live up to their schedule, we will have more tanks by the end of this year than England and France have built since the beginning of the war.

Department Reorganization

For a couple of years previous to the declaration of war by the United States, the Ordnance Department was handicapped by a lack of trained ordnance officers, as great inducements were offered them to go with different munition companies. It is greatly to the credit of a number of them that they did not leave the service. It was on these men that the task developed of reorganizing the department and preparing for war. Hundreds of reserve officers and thousands of clerks and draftsmen have had to be added to this force, in fact, it has been increased about 3000 per cent. Just the work of instructing this new force has been a great task.

Certain changes in the Ordnance Department have been made so as to consolidate into single units similar functions which under the former plan operated separately.

It was deemed advisable to supplement the military knowledge and technical experience of the regular ordnance officers with the business training and executive experience of men who had been successful in civil life. The plan of the changes contemplated segregating the divisions as they had heretofore existed and consolidating into single divisions the identical functions of each division. Thus the new operating divisions consist of four: Procurement, Production, Inspection, and Supply.

The activities of the four operating divisions are controlled from the office of the Chief of Ordnance, Acting Chief of Ordnance Brig. Gen. Wheeler, by means of three bureaus known as

a. Administration, in charge of Col. W. S. Pierce.

b. Control, in charge of Col. T. C. Dickson.

c. Engineering and Design, in charge of Col. John H. Rice.

The heads of each of these bureaus are regular army officers for many years assigned to the Ordnance Department, with a wide experience in the line of work of which they have control.

At the head of the Procurement Division has been placed Col. Samuel McRoberts, formerly vice-president and executive manager of the National City Bank of New York, a man of wide business experience.

At the head of the Production Division has been placed Col. Guy E. Trippe, formerly chairman of the board of directors of the Westinghouse Company, who was for a number of years executive head of the production of that company.

Col. B. W. Dunn now heads the Inspection Division and Col. O. C. Horney the Supply Division.

In the Control Bureau a section headed by Lieut. Col. Ralph Crews, formerly of Chicago, has for its function the final adjustment of complaints of whatever kind from manufacturers dealing with the Ordnance Department.

With all this going on, contracts for nearly two billion dollars' worth of ordnance and ammunition have been let during the last eight months. This gives some idea of the problems this department has been up against, and of the great work it is doing. We will find that in the next few months this accomplishment will be fulfilled and it will then be known that the Ordnance Department has kept faith with the people.

ADDRESS OF MAJOR ECKENFELDER

It is with great emotion that I thank you for the enthusiastic ovation tendered during this dinner. The reception I find here in America is certainly warming to the heart of a French soldier.

The gasoline engine is king of the day—on the ground, on the highways and byways, in the air, and even under the ground. I was reading a few days ago in a Chicago paper a statement, which by the way was inaccurate, in which it was said that at the beginning of the war in 1914 the British army had only 30 airplanes to start with, and that the French army had but 13. It was not as bad as that, but it was bad enough. At the beginning of the war Germany was well equipped with airplanes and had a great advantage over us.

Well, we began to work—but not as you do now here; you are starting with a purpose and with an organization. You have the benefit of experiments that we made and you are better for the faults that we committed. For a while the German attained superiority. After working very hard and experimenting very widely, we

came to be about as expert. One month they would be superior, another month we would be superior; but the German would then turn out a better engine in better apparatus and would beat us. Two months after we entered the field with a better airplane we began beating the German and sending him to the ground.

I have nothing to say that you do not know about the Liberty engine which will insure for you superiority. Some people have said that airplanes will finish the war. I don't know about that but I do know that we need 25,000 airplanes at once.

Reference was made to the way that gas engines helped to win the battle of the Marne, when all the taxis of the French capital loaded with soldiers rushed to the help of their comrades, and won the victory. That was the first use of the engine in this capacity.

Since then I saw the beginning of the battle of Verdun. I was getting out of the trenches after what seemed like three or four weeks' fighting. We did not know then what was coming, when suddenly the German heavy guns began to beat the track of the only road leading to Verdun. Well, our hearts were breaking to see that chance of defense taken from us, but this move was foreseen. I remember the first night in a little billet in a deserted town, all dismantled and broken by the bombardment. I was pleased at the prospect of a night of rest when suddenly I was urgently summoned with my company (I was a captain then) to the railroad station, and received the order to unload a train of 42 cars which we were bringing to Verdun with all kinds of provisions, fodder and oats and especially food. That train was stuck and could not go farther.

The order I received was, "Unload that train right away and load the motor trucks which are coming." That was the first time I had seen a long procession of those big motor trucks, which by the way had been made in this country to be sent to Germany. They had been bought by Germany and paid for and were taken by the British fleet and sent to us, and they brought food to Verdun.

Thousands and thousands of men began to pour down that road without stop during three days and three nights —going to death fighting for their country—and singing! The largest motor trucks were just following each other. That is what I saw the first time I had occasion to meet those motor trucks that you have been improving so much here, and which were only the first samples of what you will turn out soon.

After the entrance of the motor trucks into the war we had another surprise and the German had a surprise then—it was the fighting engine—the tanks—on the battlefield, jumping over the trenches, crawling above the wire entanglement, bursting bulwarks, blockhouses —every obstacle! Those fighting engines lately won the battle of Cambrai.

We found American engines everywhere; and not only on the battlefield, but far away from the front at the present time many American tractors are now tilling our soil, driving plows and harrows and cultivators to help us grow wheat for next year.

I cannot convey an expression of appreciation of the technical work you are doing but I know enough to see that you are doing it in a splendid way under very good management and that it will soon bring us help. You know that we did all we could to advance the progress of the engine, but we were handicapped. We were handicapped, for instance, by the losses of our coal mines. Nine-tenths of our coal mines have been in the hands of the Germans since the beginning of the war. Nevertheless think of the effort we made!

Before the entrance of the United States into the war we distributed among our allies, the Russians, the Roumanians, the Serbians and the Italians 1,350,000 rifles, 15,000 light machine guns, 10,000 heavy machine guns, 800,000,000 rounds of ammunition! We sent them 1300 field guns, 1200 heavy guns, 4750 airplanes, and now we are pleased to be able to supply you and to insure your consumption in guns during the full year of 1918. You will have no trouble with that.

ATTENDANCE AT THE CHICAGO MEETING

MEMBERS

Albee, Wm. N., Wm. N. Albee Co., *Detroit.*
Anderson, Wm. C., Anderson Engine Co., *Chicago.*
Andrews, Geo. C., Andrews Tractor Co., *Minneapolis.*
Appleton, Joseph, The Turner Mfg. Co., *Port Washington, Wis.*
Apple, Vincent G., Vincent G. Apple Research Laboratories, *Dayton, Ohio.*
Austin, R. W., Gramm Bernstein Motor Truck Co., *Lima, Ohio.*
Bachman, B. B., The Autocar Co., *Ardmore, Pa.*
Bott, Geo. R., The Norma Co. of America, *New York.*
Barthel, Oliver E., 302 Moffat Bldg., *Detroit.*
Bateman, J. R., Hyatt Roller Bearing Co., *Chicago.*
Batenburg, P. J. F., Four Wheel Drive Auto. Co., *Clintonville, Wis.*
Bendix, Vincent, Brandenburg & Co., *Chicago.*
Bell, George, Remy Electric Co., *Detroit.*
Berry, H. C., National Tractor & Machine Co., *Chicago.*
Buffington, H. C., Minneapolis Steel & Machinery Co., *Minneapolis.*
Bull, A. A., Northway Motor & Mfg. Co., *Detroit.*
Chryst, W. A., Dayton Engineering Laboratories Co., *Dayton, Ohio.*
Coble, E. W., E. W. Coble Co., *Toledo, Ohio.*
Cotta, Chas., Cotta Gear Co., *Rockford, Ill.*
Cox, Henry G., Magneto Dept., International Harvester Corp., *Chicago.*
Coyle, J. F., *Penfield, Ill.*
Crawford, C. S., Premier Motor Corp., *Indianapolis.*
Cumner, A. B., Autocar Co., *Washington.*
Davis, R. E., Advance Rumely Co., *Laporte, Ind.*
Diefendorf, H. G., Gray Motor Co., *Detroit.*
Dick, W. A., Westinghouse Electric & Mfg. Co., *Pittsburgh.*
Dick, Burns, Wagner Electric Co., *St. Louis.*
Dixon, Edward, Dayton-Dick Co., *Quincy, Ill.*
Donaldson, F. A., captain, Ordnance Department, *Washington.*
Dietzel, Alexander W., Waukesha Motor Co., *Waukesha, Wis.*
Eason, C. M., Hyatt Roller Bearing Co., *Chicago.*
Falvey, M. B., 1430 Michigan Ave., *Chicago.*
Fisher, J B., Waukesha Motor Co., *Waukesha, Wis.*
Fliedner, Carlyle, captain, Ordnance Department, *Rock Island, Ill.*
Foote, John B., Foote Bros. Gear & Machine Co., *Chicago.*
Franklin, G. King, Room 301, Herald Bldg., *Chicago.*
Gaidzik, G. W., The Ohio Nash Co., *Cleveland.*
Gemlo, James, Toro Motor Co., *Minneapolis.*
Gernandt, W. G., Peoples Gas Bldg., *Chicago.*
Gillespie, A. J., S. K. F. Ball Bearing Co., *Hartford, Conn.*
Greenlee, James T., Imperial Brass Mfg. Co., *Chicago.*
Greer, E. R., Emerson-Brantingham Co., *Minneapolis.*
Gunlogson, G. B., J. I. Case Threshing Machine Co., *Racine, Wis.*
Halbleib, Joseph C., North East Electric Co., *Rochester, N. Y.*
Harrison, O. L., Dayton Engineering Laboratories Co., *Dayton, Ohio.*
Hendrickson, R. T., Hendrickson Motor Truck Co., *Chicago.*
Hotz, Geo. J., The Hotz Foundry & Mfg. Co., *Fremont, Ohio.*
House, B. E., Pan Motor Co., *St. Cloud, Minn.*
Hovey, W. S., Fairbanks Morse Mfg. Co., *Beloit, Wis.*
Hunt, J. H., Dayton Engineering Laboratories Co., *Dayton, Ohio*
Jeffries, Carl F., Detroit Truck Co., *Detroit.*
Jennings, I. L., Lamson & Sessions Co., *Cleveland.*
Johnson, H. S., Westinghouse Electric & Mfg. Co., *Pittsburgh.*
Jones, D. W., Diamond T Motor Car Co., *Chicago.*
Johnston, E. A., International Harvester Co., *Chicago.*
Kanters, L. M., Waukesha Motor Co., *Waukesha, Wis.*
Keim, L. H., R. D. Nuttall Co., *Chicago.*
Kelly, Moore, Byrne Kingston & Co., *Detroit.*
King, H. O., Phenix Truck Makers, Inc., *Chicago.*
Knobloch, Alvin F., Cleveland Tractor Co., *Cleveland.*
Knobloch, W. H., Cleveland Tractor Co., *Cleveland.*
Kranich, F. N. G., Hyatt Roller Bearing Co., *Chicago.*
Krenzke, Wm. F., J. I. Case Threshing Machine Co., *Racine, Wis.*
Lake, E. F., Rich Tool Co., *Chicago.*
Leece, B. M., Leece-Neville Co., *Cleveland.*
Leonard, Howard G., The Leonard Tractor Co., *Jackson, Mich.*
Leoni, A. M., P. T. Wheel Co. of America, *Dayton, Ohio.*
Lentz, S. F., The Texas Co., *Detroit.*
Lewis, G. L., The Lewis Electric Welding & Mfg. Co., *Toledo, Ohio.*
Ludolph, Fred E., Harvey Motor Truck Co., *Harvey, Ill.*

MATHER, G. C., Paige-Detroit Motor Car Co., *Detroit*.
MILLER, DAVID R., Service Motor Truck Co., *Wabash, Ind.*
MONAHAN, L. J., Universal Motor Co., *Oshkosh, Wis.*
MOORE, F. C., 710 Engineers Bldg., *Cleveland*.
MOORE, MEADE F., Nash Motors Co., *Kenosha, Wis.*
NILSON, HAROLD, Nilson Tractor Co., *Minneapolis*.
NILSON, LEONARD, Nilson Tractor Co., *Minneapolis*.
NORRIS, CHARLES D., Burlington Motor Truck Co., *Chicago*.
OETTING, O. W. A., Willard Storage Battery Co., *Cleveland*.
PARKER, F. W., JR., 1410 Marquette Bldg., *Chicago*.
PARKER, G. E., Sheffield Car Co., *Three Rivers, Mich.*
PARRETT, DENT, Parrett Tractor Co., *Chicago*.
PATITZ, J. F. MAX, Allis-Chalmers Mfg. Co., *Milwaukee*.
PENDOCK, C. W., Le Roi Co., *Milwaukee*.
PETERS, JEAN, Willys-Overland, Inc., *Toledo, Ohio*.
PETERSON, FRANK LEROY, Holt Mfg. Co., *Peoria, Ill.*
PETIT, W. H., Pan American Motors Corp., *Decatur, Ill.*
PETTY, WALTER M., Service Motor Truck Co., *Wabash, Ind.*
PFEIFFER, CLARENCE, Armour Institute of Technology, *Chicago*.
PHILIPS, EDWIN S., Philips-Brinton Co., *Kennett Square, Pa.*
PLIMPTON, R. E., S. A. E., *New York*.
PUTNAM, W. H., Madison-Kipp Lubricator Co., *Madison, Wis.*
REID, WILLIAM A., J. I. Case Threshing Machine Co., *Racine, Wis.*
REIFSNIDER, CHAS. L., Midland Publishing Co., *St. Louis*.
RENO, J. F., R & V Engine Co., *East Moline, Ill.*
RIDER, FRANK J., S. K. F. Ball Bearing Co., *Hartford, Conn.*
RICKER, CHESTER S., Ricker Oil Co., *Indianapolis*.
ROSE, PHILIP S., Curtis Publishing Co., *Chicago*.
RUDOLPH, WALTER J., Imperial Brass Mfg. Co., *Chicago*.
RUSSELL, T. A., Willys-Overland, Ltd., *West Toronto, Ont.*
SARGENT, C. E., Lyons-Atlas Co., *Indianapolis*.
SALFISBERG, LEROY L., Gray-Plano Co., *Plano, Ill.*
SCARRATT, A. W., Minneapolis Steel & Machinery Co., *Minneapolis*.
SCHAEFER, C. T., Globe Motor Truck Co., *St. Louis*.
SCHEFFERLY, ROBT. J., Wichita Falls Motor Co., *Wichita Falls, Texas*.
SCHIPPER, J. EDWARD, Class Journal Co., *Detroit*.
SCHOENROCK, OTTO R., Bureau of Engineering, City of Chicago, *Chicago*.
SCHMIDT, HUGO F., 910 S. Michigan Ave., *Chicago*.
SCHWITZER, LOUIS, The Oakes Co., *Indianapolis*.
SHOOP, R. B., McVicker Engineering Co., *Minneapolis*.
SILVER, W. H., Deere & Co., *Moline, Ill.*
SKINNER, H. C., The Class Journal Co., *Chicago*.
SLONNEGER, J. C., Holt Mfg. Co., *Peoria, Ill.*
STEBBINS, C. B., Climax Engineering Co., *Clinton, Iowa*.
STEELE, FRED. P., Lyons Atlas Co., *Indianapolis*.
STRITE, GEO. T., Fifth Ave. Bldg., *New York*.
STRITMATTER, ALBERT, *Farm Implement News, Chicago*.
SWEET, ERNEST E., Henry M. & Wilfred C. Leland, *Detroit*.
SWENSON, C. E., Mechanics Machine Co., *Rockford, Ill.*
SZEKELY, OTTO E., Velie Motors Corp., *Moline, Ill.*
THOMAS, H. M., Anderson Engine Co., *Chicago*.
TRASK, CHAS. A., Rockwood Mfg. Co., *Indianapolis*.
TRUMBULL, GEO. B., 175 West Jackson Blvd., *Chicago*.
TURNER, L. M., The Turner Mfg. Co., *Port Washington, Wis.*
VANDERBEEK, H., The Timken-Detroit Axle Co., *Detroit*.
VAN NORTWICK, JOHN, Appleton Mfg. Co., *Batavia, Ill.*
WAHLBERG, ERIC, Nash Motors Co., *Kenosha, Wis.*
WATTS, FRANK E., Hupp Motor Car Corp., *Detroit*.
WEIDELY, GEO. A., Weidely Motors Co., *Indianapolis*.
WHITBECK, J. V., Chandler Motor Car Co., *Cleveland*.
WHITNEY, CHARLES S., Willard Storage Battery Co., *Chicago*.
WILEY, C. O., Byrne, Kingston Co., *Kokomo, Ind.*
WILKIE, J. CHESTER, Western Automatic Machine Screw Co., *Elyria, Ohio*.
WITRY, L. W., Waterloo Gas Engine Co., *Waterloo, Iowa*.
WOOLER, ERNEST, Chandler Motor Car Co., *Cleveland*.
WORTHINGTON, WAYNE H., The Electric Wheel Co., *Quincy, Ill.*
YOUNG, O. W., Hyatt Roller Bearing Co., *Minneapolis*.
ZAGORA, JOSEPH, Mitchell Motor Co., Inc., *Racine, Wis.*

GUESTS AT THE CHICAGO MEETING

ADAMS, C. R., Sibley Machine Tool Co., *South Bend, Ind.*
*ALLEN, G. EDGAR, Allen, Latimer & Co., Inc., *Detroit*.
ARNOLD, D. L., 5526 West Monroe St., *Chicago*.
BALLENTINE, R. W., 1843 Peoples Gas Bldg., *Chicago*.
BARRETT, GEO. F., *Moorefield, Neb.*
BAER, CARL J., *Chicago*.
BARTLETT, G. M., Diamond Chain & Mfg. Co., *Indianapolis*.
BENNETT, F. H., *E. Las Vegas, New Mexico*.
BIERMAN, F. H., Strite Gov. Pulley Co., *Minneapolis*.
BRINEY, H. C., McCormick Bldg., *Chicago*.
*CARINGTON, ROBT. W., Standard Oil Co. of Indiana, *Chicago*.
CARSON, W. L., *Moline, Ill.*
CALKINS, ADDISON N., Electric Wheel Co., *Quincy, Ill.*
COAPMAN, J., U. S. Ordnance Dept., Holt Mfg. Co., *Peoria, Ill.*
COLLINS, G. C., 110 Jessie St., *San Francisco*.
*CRAVENS, GEORGE WAVERLEY, Elkhart Carriage & Motor Car Co., *Elkhart, Ind.*
DASEY, P. J., Buda Co., *Harvey, Ill.*
*DAY, ALFRED L., 684 Harwood Drive, *Des Moines, Iowa*.
*DEAN, F. A., Hyatt Roller Bearing Co., *Chicago*.
DENNING, J. M., National Tractor Co., *Chicago*.
DEWEY, HOWARD, *Plano, Ill.*
DICKERSON, I. W., Standard Farm Papers, *Charles City, Iowa*.
DONALDSON, W. H. L., Donaldson Engineering Co., *St. Paul, Minn.*
FAIRMAN, H. E., *Davenport, Iowa*.
FERTNER, C. P., Standard Oil Co., *Minneapolis*.
GEYLER, E. H., Kokomo Electric Co., *Kokomo, Ind.*
GILBERT, A. H., Vacuum Oil Co., *Chicago*.
GOLDBERGER, ERNEST, Packard Motor Car Co., *Detroit*.
GOODSPEED, CHARLES A., Mailometer Co., *Detroit*.
GRAHAM, R. A., Graham Bros., *Evansville, Ind.*
GRUBER, R. L., Monarch Machine Works, *Milwaukee*.
GUMPER, H. M., The Sparks-Withington Co., *Jackson, Mich.*
HALL, GUY H., Kansas City Tractor Club, *Kansas City, Mo.*
HOORIS, G. D., National Tractor & Machinery Co., *Chicago*.
HARRISON, F. H., Plano Works, *West Pullman, Ill.*
HAWLEY, R. C., Mitchell Motors Co., Inc., *Racine, Wis.*
HITCHCOCK, R. C., Modern Pattern Co., *Minneapolis*.
HISCHE, HARRY, 20 East Jackson Blvd., *Chicago*.
HORNING, WM. S., *Waukesha, Wis.*
*HUNT, L. G., Moline Plow Co., Tractor Branch, *Moline, Ill.*
HOBART, F. G., *Beloit, Wis.*
*IKERT, B. M., Class Journal Pub. Co., *Chicago*.
JANNEY, P. R., Maxwell Motor Co., *Detroit*.
JOHNSON, N. G., 9 North Harrison St., *Batavia, Ill.*
JANATASCH, JOS., *Plano, Ill.*
KEENE, CHAS. F., Ensign Carburetor Co., *Los Angeles*.
KERR, R. H., Appleton Mfg. Co., *Batavia, Ill.*
KULICKE, F. W., Atwater Kent Mfg. Works, *Philadelphia*.
LAMBERT, H. E., Pan Motor Co., *St. Cloud, Minn.*
LAMSON, G. W., 110 South Dearborn St., *Chicago*.
LARSON, D. N., 1227 Sprague Ave., *Spokane, Wash.*
LAYMAN, H. B., Layman Pressed Rod Co., *New York*.
LITLE, THOMAS J., JR., Lincoln Motor Co., *Detroit*.
*LORD, CHAS. E., International Harvester Co., *Chicago*.
LORD, K. A., W. N. Albee Co., *Detroit*.
MAXWELL, J. D., 121 N. Broadway, *Tarrytown, N. Y.*
MCCARTNEY, E. B., Toro Motor Co., *Minneapolis*.
MALTHOUSE, C. A., Nilson Tractor Co., *Minneapolis*.
MANSFIELD, J. H., Cotta Gear Co., *Rockford, Ill.*
MARTIN, C. H., Martin Rocking Fifth Wheel Co., *Springfield, Mass.*
MARSH, W. L., Packard Electric Co., *Detroit*.
MEISTER, H. O. K., Hyatt Roller Bearing Co., *Chicago*.
MERCER, W. D., Detroit Pitter Fan Co., *Detroit*.
MEREDITH, G. M., 729 Roosevelt Ave., *Detroit*.
MERZ, A. D., Madison-Kipp Lubricator Co., *Madison, Wis.*
MIQUELON, P. E., Zenith Carburetor Co., *Detroit*.
*MOHR, A. F., Hyatt Roller Bearing Co., *Chicago*.
MUSTIN, H. S., Strites Mar Farm Tractor Co., *Chicago*.
NEWILL, E. B., Westinghouse Electric & Mfg. Co., *East Pittsburgh, Pa.*
PALMER, H., Kissel Motor Car Co., *Hartford, Wis.*
PARSONS, H. N., U. S. Ball Bearing Mfg. Co., *Chicago*.
REED, C. O., George Batten Co., *Chicago*.
RITCHIE, P. C., Westinghouse Electric & Mfg. Co., *East Pittsburgh, Pa.*
ROBINSON, F. S., Lyons Atlas Co., *Indianapolis, Ind.*
ROSENTHAL, A. E., American Tractor Corp., *Peoria, Ill.*
SANDERS, JOHN H., Appleton Mfg. Co., *Batavia, Ill.*
*SAWYER, E. N., Cleveland Tractor Co., *Cleveland*.
SHERMAN, LOUIS A., 1461 Monadnock Block, *Chicago*.
SKINNER, A. A., The Leece-Neville Co., *Cleveland*.
SLADKY, JOS. F., Nash Motors Co., *Racine, Wis.*
SMITH, C. A., 1350 McCormick Bldg., *Chicago*.
SMITH, W. N., Monarch Tractor Co., *Watertown, Wis.*
SPAULDING, FENTON J., Tractor & Truck Dept., Link-Belt Co., *Chicago*.
SQUIRE, F. W., *Farm Implement News, Chicago*.
SUOBBLE, J. E., *So. Haven, Mich.*
*STACK, JNO. W., Standard Oil Co., *Chicago*.
*STAHL, A. C., New Departure Mfg. Co., *Bristol, Conn.*
SWAN, E. A., Advance Rumely Co., *Laporte, Ind.*
THOMPSON, J. A., *Avery, Iowa*.
VREELAND, A. P., Mitchell Motors Co., *Racine, Wis.*
WAITE, H. C., Elgin Motor Corp., *Piqua, Ohio*.
WHITE, GEO. A., The Sparks-Withington Co., *Jackson, Mich.*
WOODS, JOHN J., Appleton Mfg. Co., *Batavia, Ill.*
WOODS, EARL, J. I. Case Plow Works, *Racine, Wis.*
ZELLE, WILLIAM C., 321 Wainwright Bldg., *St. Louis*.
ZOLLINGER, F. T., Timken-Detroit Axle Co., *Detroit*.

*Applicants for membership.

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Fundamentals of Tractor Design

By GEORGE T. STRITE* (*Member of the Society*)

CHICAGO TRACTOR MEETING PAPER

THE fundamental design of a tractor involves first the size of the tractor, the number of plows it will pull, or the drawbar pull. For many years the tendency has been to keep increasing the size just a little more. Even in the days of the big tractor, eight and ten-plow, I can remember when the influence exerted by our customers for just a little more power was hard to resist. The temptation was continually before us to build something larger, although at that time most of us knew that in time the small tractor was going to be the thing.

Since the complete readjustment of the tractor manufacturing business, most companies have started with the two and the three-plow outfit and ever since there has been a constant demand for just a little more pulling capacity. One of the hardest things in the tractor business is to have the nerve to "stand pat" and build one size and not keep constantly increasing the size so that it will do a little more work.

Power and Traction

After the size has been determined, we have two factors to deal with—one, the *amount of power;* the other is *traction.* Here again is a hard question to decide, whether to have sufficient power so that the engine will not stop and will continually turn the wheels regardless of the kind of ground or footing; or, on the other hand, shall we install an engine with only sufficient power to carry the load and turn the wheels. If an engine develops five or ten horsepower more than would be required for the ordinary work, then the entire transmission and tractor must have sufficient strength to take care of the load and turn the wheels under extreme conditions. Would we think of buying an automobile today with engine, transmission, and bearings of such capacity as to spin the wheels of the automobile on high gear and dry ground? This would be absurd in an automobile.

However, from a sales point of view, there is one reason why we have done this in the case of the tractor. In demonstrating the tractor, at which time it is generally loaded to the limit, if we stall the engine, it is most discreditable to the tractor; if the engine has sufficient power to keep on turning the wheels, even to the extent of burying the tractor in the ground, this brings out an applause for the tractor, and the farmers will say: "Gee, but that tractor has got the power!"

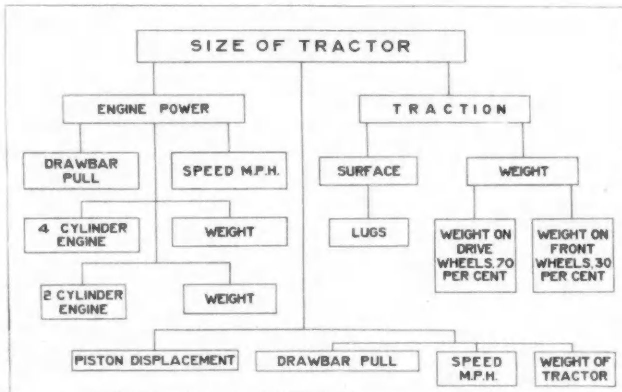
Personally, I think that we have carried this to extremes. What the average wheel tractor needs is more traction as compared to the amount of power furnished. The farmer would then get a more efficient and better balanced machine, a machine that could be used in extremely bad conditions, on wet, soft, or on sandy ground. As soon as the farmer is educated on this point, we will begin to build tractors better balanced for total average efficiency, and not those that will do certain tricks, regardless of the average work they are expected to do. The farmer or manufacturer will then use more horse sense and good judgment with an eye to final average efficiency.

*Consulting Engineer, Strite Tractor Company.

When we have settled the ratios between power and traction the third item to consider in the design of a tractor is the bearing surface of the wheels on the ground as compared to the power of the tractor. In the old days we built tractors which were exceedingly heavy and deficient in surface. The future tractor and even the tractor of today is being built with less weight because of multiple-cylinder engines, high-grade material, and greater wheel surface on the ground. The wheel surface must also be backed up by the proper shape and style of grounders or lugs.

Weight Distribution

After the total weight of the tractor is determined, then comes the question of distribution of total weight. If it is a four-wheel machine with two drivers in the rear and two front wheels careful judgment must be used as to how much weight should be carried on the drive wheels and how much on the front wheels. With the best practice today about 70 per cent of the total weight seems to be carried on the drive wheels and about 30 per cent on the front wheels. This weight must be calculated with the tractor standing still, without any drawbar load.



FACTORS AFFECTING TRACTOR DESIGN

When the tractor is working with a reasonably heavy drawbar pull, from 85 to 90 per cent of the total weight of the tractor, plus a certain percentage of the drawbar pull will be carried on the rear wheels. This percentage depends upon the height of the drawbar hitch on the tractor, the height of the hitch on the plow and on the load being pulled. From 10 to 15 per cent of the weight is thus carried on the front wheels, which for all practical purposes is enough to steer the tractor, except when going up a steep grade, when the front wheels are apt to rise and make hard steering.

The power required of the tractor engine depends upon first, the drawbar pull, which, however, has no significance unless the speed is considered. It takes practically the same power to pull two plows at three miles per hour as to pull three plows at two miles per hour. This is a point where the farmer has been greatly deceived. Some companies have sold their tractors on

the basis of drawbar pull in pounds, saying nothing about the speed in miles per hour, while other companies have made a strong point of the speed. Both, of course, must be considered in determining the drawbar horsepower.

From an engineering standpoint, and I think eventually, for the convenience of the farmer, the power should be specified in figures of total displacement. In the figures in the accompanying table the speed of the different tractors will not be considered. In group A there is little difference in the speed of the three machines. In group B in actual practical farm work there is surprisingly little difference in the speed, although there is a difference between group A and groups B and C, as the speed of the small tractors will average from 10 to 15 per cent higher. However, for the sake of comparison, we will disregard the speed.

Out of 95 different models in the tractor specification books, I have taken 10 of the best known makes, all of which have 500 or more tractors actually in the field. The first three in group A are of the large type, two with 2-cylinder and one with a 4-cylinder engine. Group B represents the four-cylinder, three and four-plow tractors of late models and light weight. In group C we have three of the two-cylinder, three and four-plow tractors of recent but possibly not of the latest design.

For comparison, I will take up: First, the piston displacement in cubic inches per minute, for each 14-in. plow pulled.

Second, the piston displacement, for each rated 100-lb. drawbar pull.

Third, the piston displacement for each rated drawbar horsepower.

Fourth, the weight of tractor for each 14-in. plow pulled.

Fifth, the weight of tractor for each 100-lb. drawbar pull.

Sixth, the weight of tractor for each rated drawbar horsepower.

In Col. 9, for example, tractor A-1 has a piston displacement of 147,250 cu. in. per min. for each 14-in. plow pulled. Tractor A-2 has a piston displacement of 86,206 cu. in. per min. for each plow pulled. Tractor A-3 has a piston displacement of 88,312 cu. in. per min. for each plow pulled.

In Col. 9 the average piston displacement of the three tractors in group A is 107,256 cu. in. per min. per plow.

The average piston displacement per minute per plow of the four tractors in group B is 91,540, or about 15,000 cu. in. less than in group A.

The average piston displacement per minute per plow of the three tractors in group C is 85,771, or 21,000 cu. in. less than in group A. The two-cylinder tractors in group C have less displacement per minute, or less power per plow, than have those of group B, the four-cylinder machines of the same size.

In Col. 10, group A, the average piston displacement per 100 lb. drawbar pull is 14,581 cu. in. per minute. In group B this displacement is 11,247 cu. in., or about 3300 cu. in. less than the corresponding figure for group A. In group C the displacement is 12,164 cu. in., so that the displacement is 900 cu. in. more than that in group B, and 2400 cu. in. less than that in group A per 100 lb. drawbar pull.

CHARACTERISTICS OF TEN WELL-KNOWN MAKES OF TRACTORS

Tractor Groups	Horsepower Drawbar Brake 1	Drawbar Pull, Lb. 2	No. of Plows 3	No. of Cylinders 4	Cylinder Dimensions, In. Bore Stroke 5	Engine, R.P.M. 6	Cubic Inches Piston Displacement Per Rev. 7	Total per Minute 8	Per Plow 9	Per 100 Lb. Drawbar Pull 10	Per Drawbar Hp. 11	Piston Travel per Minute in Ft. 12	Pounds Weight Of Tractor 13	Per Plow 14	Per Drawbar Hp. 15	Per 100 Lb. Drawbar Pull 16
A-1......	38-60	6,000	8	2	10x15	500	2,356	1,178,000	147,250	19,633	31,000	1,250	20,100	2,512	529	335
A-2......	30-60	6,000	8	4	6½x8	650	1,061	689,650	86,206	11,494	22,988	866	19,500	2,437	650	325
A-3......	30-60	5,600	8	2	10x12	375	1,884	706,500	88,312	12,616	23,550	750	26,000	3,250	866	464
Averages..	.....	**5,866**	.....	.....	....	.....	.....	....	**107,256**	**14,581**	**25,846**	**955**	**21,866**	**2,733**	**681**	**374**
B-1......	12-20	2,250	3	4	4½x5	800	318	254,400	84,800	11,563	21,200	666	6,500	2,166	542	295
B-2......	18-36	3,300	3	4	4½x6¾	850	429	364,650	91,162	11,050	20,258	956	5,900	1,475	327	178
B-3......	12-25	2,500	3	4	4¼x5½	900	312	280,800	93,600	11,232	33,400	825	5,200	1733	433	208
B-4......	15-30	2,600	3	4	4¼x5¾	900	322	289,800	96,600	11,146	19,320	862	3,000	1,000	200	115
Averages..	.....	**2,661**	.....	.....	....	.....	.....	....	**91,540**	**11,247**	**23,544**	**827**	**5,150**	**1,593**	**375**	**199**
C-1......	12-24	2,200	3	2	6x7	750	395	296,250	98,750	13,465	24,687	875	5,000	1,666	416	227
C-2......	12-24	2,000	3	2	5½x7	750	332	249,000	83,000	12,450	20,750	875	5,000	1,666	416	250
C-3......	12-25	2,500	3 or 4	2	6½x7	570	464	264,480	75,565	10,579	22,040	665	7,400	2,114	616	296
Averages..	.....	**2,233**	.....	.....	....	.....	....	....	**85,771**	**12,164**	**22,728**	**802**	**5,800**	**1,815**	**482**	**257**

drawbar pull.

In Col. 11, group A, the average piston displacement for each rated drawbar horsepower is 25,846 cu. in. per minute. In group B, the displacement is 23,544 cu. in. per minute. The displacement is 22,728 cu. in. in group C, so that the four-cylinder machines in group B have 700 cu. in. more displacement.

In Col. 13 the weights of the three different *groups of tractors* are compared. The average weight of the three large tractors in group A is 21,866 lb.; the average weight of the four-cylinder tractors in group B is 5150 lb.; and the average weight of those in group C, the two-cylinder tractors, is 5800 lb. or 650 lb. more per tractor than the four-cylinder machine. The average drawbar pull of group B tractors is 429 lb. more than that of the group C two-cylinder machine.

In Col. 14 are compared the weights for each 14-in. plow pulled. The average weight of the large tractor in group A is 2733 lb. for each 14-in. plow pulled.

The average weight of the group B tractors, the four-

cylinder three and four-plow machines, is 1593 lb., or nearly 1200 lb. less than was the case with the group A tractors.

The average weight in group C two-cylinder tractors is 1815 lb. for each 14-in. plow pulled, or nearly 250 lb. more than for the average four-cylinder machine, and about 1100 lb. less than for the group A tractors.

In Col. 15 we come to the comparative weight of the tractor for each rated drawbar horsepower. In the large tractor the average tractor weight is 681 lb. for each rated drawbar horsepower. In group B the four-cylinder tractor's average weight is 374 lb.; and in group C the tractor weight for the two-cylinder tractor is 482 lb. for each drawbar horsepower, or 108 lb. more than for group B and 200 lb. less than for the group A tractors.

Col. 16 gives the comparative weight for each 100 lb. of rated drawbar pull. In group A this is 374 lb.; in group B 199 lb., or 75 lb. less than was the case for group A; in group C the average is 258 lb. of tractor weight for each 100 lb. of drawbar pull, or 58 lb. more than for group B and 117 lb. less than for group A.

In these three groups of tractors the highest rate of piston travel is in group A and the highest revolutions per minute is in groups B and C.

Both the four-cylinder and two-cylinder late type tractor show a wonderful development, especially so in regard to the weight per plow and per horsepower. The large tractor should weigh less for each plow and for 100 lb. of drawbar pull than the small tractor because in a one or two-plow tractor the initial weight of the tractor itself is great, as it is distributed over only one of two plows. The more plows we have to take this weight, the less the weight for each plow.

For instance, it takes an initial weight of from 1500 to 2000 lb. to pull one 14-in. plow, from 500 to 1000 lb. more to pull two plows, and from 300 to 700 lb. additional to pull the third plow. This also affects the power or displacement for the machine itself.

There is some variation in these average figures, which I think is caused by the fact that some tractors are overrated in drawbar horsepower and drawbar pull, while others are conservatively rated. As a rule, the four-cylinder machine is in a higher state of development than the two-cylinder machine. In one case the rated drawbar pull is almost equal to the entire weight.

There is a question as to how far we can go in reducing the weight per 100 lb. of drawbar pull for practical everyday use on the average conditions of soil. I believe we can eventually build tractors so that they will pull more than their weight, providing the speed is not too high, and that they are, as it were, geared to the ground, when used in certain sections where this is possible. I think this is not possible for average conditions.

The Future of the Tractor

There is a big field in certain sections and for certain uses for the track-laying machine, but the wheel machine will be the popular machine and the big seller for average agricultural purposes.

Tractor engineers have been severely criticized in some cases for the past and present state of the tractor, with its different designs.

From now on, the tractor industry will advance either through the natural evolution of the right tractors succeeding and the wrong gradually dying out, or by the tractor engineers and manufacturers getting together and *through standardization* avoiding failures that otherwise must come sooner or later.

The tractor manufacturers of today have the greatest opportunity that any manufacturing industry has ever had in the history of the world. They have an opportunity of carrying standardization farther and more successfully and with the least resistance, if they will get together, work together, and through the Society of Automotive Engineers, assist in adopting the necessary standards.

It has been said that the automobile manufacturers will try to enter the tractor industry. They are going to get in, and personally I believe that the sooner they get in, the better. They will probably spend fortunes to learn just what many of us have learned, but the automobile manufacturer has four great advantages over the tractor manufacturer.

First, he has the money, and is looked up to by the investor as a successful business man.

Second, he knows how to get production, and he has the organization and equipment for it.

Third, by past experience with the automobile he knows the value of standardization, and will help to standardize the parts of tractors.

Fourth, he has learned to cut out petty ideas, and to work for average results.

The tractor business is an important one. It is going to be one of the greatest in volume of business of any one business in the world. The tractor means more to the general happiness and welfare of mankind than any other machine that has ever been brought out in the history of the world. It is going to entirely change the farm power of all the world, and, further, it will revolutionize farming itself; better methods will mean more food for the world at far less cost.

Considering the state of the tractor industry at this time, the inability of the companies to produce tractors fast enough, and the quality of the tractors turned out, I believe that the Government should design and build a "Liberty" tractor to be manufactured by it during the war and to be open to any company to make, or to adopt any part of, as they see fit, after the war. The corps of engineers that design and build this machine should have instructions to do no experimenting, but to follow the lines of the best in the tractor as it is today.

This move would do more to bring about standardization and the eventual tractor than any other move that could possibly be made. It will result in the greatest good to all and especially to the tractor manufacturer. The war has already demonstrated the necessity and advantages of standardization of other machines, so why not of the tractor?

THE DISCUSSION

H. L. HORNING:—It seemed to be the concensus of opinion of the members of the S. A. E. in Washington that, although they had participated in the standardization of two of the notable mechanical achievements of the war, namely the Liberty engine and the motor truck, they did not feel that the tractor industry was old enough to submit to the process of standardization. It appears that something like 5 to 7 per cent of the potential tractor market has not yet been filled by tractors, and if that is true, we have not even 5 to 7 per cent of the knowledge that is possible in regard to tractors.

Time Not Ripe for Standardization

We are just starting on the era of great things for the tractor. It seems to me there never was a body of men who realized the value of standardization and its proper application as the Society, and I would feel a great regret if we attempted to go too far at this time

in standardizing the tractor, but I hope that no one will take my remarks to mean that we should not go as far as possible and as fast as possible in the standardization of numerous things going to make up tractors.

PRESIDENT KETTERING:—Mr. Strite spoke about those in the automobile field going into the tractor business. There is one thing they have got to learn—that a tractor pulling three plows doesn't coast very much of the time.

Mr. Ford once said to me, "I didn't think there was so much difference between an automobile engine and a tractor engine." I don't believe he has found out all the differences yet.

Keeping Dust Out of Carbureters

P. J. DASEY:—Erom my point of view, being in the engine business, the first vital thing of importance to the internal combustion engine industry and all those associated with it is to devise some way of keeping sand and fine silicate dust out of carbureters. Otherwise there will be no use to standardize anything for tractors.

The second is a positive governor which will control speeds and keep them within practical working limits. One idea today seems to be to install the gas engine regardless of the tractor, overload the tractor to the limit, run the speed up beyond what the tractor was originally built for, raise the engine speed beyond its extreme limit, and then blame the engine manufacturer. The engine should be sufficiently large to do the work without running it to the extreme limit.

By following these two suggestions the gas-engine tractor will be put on a much sounder basis. Otherwise I think we are going to see the red flag of revolt go up and steam becoming the prevailing power.

R. E. DAVIS:—There is still a wide gulf between the automobile engineer and the tractor engineer. Each can learn something from the other. The automobile engineer has learned through years of practice since the beginning of the automobile industry to inclose the parts and as far as possible to lubricate them automatically. In other words, do away with the numerous grease cups which require attention, and make the tractor so it will take care of itself.

The farmer's policy of lubrication is "let it squeak for oil first." We ought to provide a means of automatically taking care of lubrication. The farmer is in a rush in the busy season and he will neglect to tighten the grease cups. From some of the tractor designs I have seen I wouldn't blame him if he did neglect some of them.

PRESIDENT KETTERING:—In studying this tractor situation it seems to me that we have, in addition to a great mechanical problem, one of the greatest psychological problems that we have ever had. There is no use starting out to educate the farmer by getting out a little instruction book. We should make the tractor so that he will not have to be educated.

TRACTOR WEIGHT AND FUEL ECONOMY

(Discussion contributed after adjournment)

ERNEST GOLDBERGER:—The law of averages, as a principle for finding the truth from catalogs of tractors on the market, fails completely in any problem of tractor engineering as in any branch of human activity that is still groping its way in the dark. In the early dawn of tractor design, farmers with insufficient engineering and manufacturing experience, and automobile engineers with only a hasty consideration of the farmers' needs, started building tractors from opposite ends, hence such a variety of sizes, types, and weights of tractors. A tractor, containing features obtained by averaging those of tractors already on the market, would not present the most progressive features, of which there is much need at the present time.

To the question, "How many pounds pull per 100 lb. weight should a tractor develop at the drawbar?" almost any figure from 10 to 100 would be found to apply to the types on the market, and yet, with the exception of what the size of a tractor should be, this is the most important question for the manufacturer to know. That all these tractors have traction to a certain extent cannot be denied; therefore, the problem reduces itself to a question of economy. By reducing the weight of the tractor the fuel economy is necessarily increased, but on the other hand the cost of material, that is, the initial cost of the tractor is increased. Which is, then, the most economical weight?

Suppose we consider three types of tractors: The heavy-wheel tractor which gets its traction mostly due to adhesion (friction), or lugs (not higher than 1¼ in.); the light-weight tractor, which gets its traction from the paddlewheel effect of the high spikes or grouters, which sink into the ground, hold the wheel for a while, and, in revolving, plow a shovelful of ground with every grouter; and, finally, the creeper type, which again gets traction mostly by adhesion, but sinks less into the ground.

German Motor-Plowing Contest

At one of the most scientific motor-plowing contests that I know of (Klein-Wanzleben in Germany in 1913), at which both European and American tractors of all types were well represented, every tractor was hauled over the field and the required pull and its weight compared. The official report (published in *Motorwagen* of July 20, 1914) may be considered reliable, as it was published before the war.

The results were:

1. Creeper tractor (American, one only) required a pull of 11.1 per cent of its weight for propulsion.
2. Heavy-wheel tractors required from 16.1 to 19.3 per cent.
3. Light-weight tractors (all German make) required from 17.2 to 21.9 per cent.

Assuming as correct, averages of 11.1 per cent for creepers, 17.7 per cent for adherence wheel tractors, and 20 per cent for paddlewheel tractors, and assuming further a speed of 2.5 m.p.h., a tractor life of 4500 hours of work, a fuel consumption of 0.75 lb. of gasoline per hp-hr., and a cost of $0.20 per gal. of gasoline (proportionate cost of oil included), we find that, if, by saving one pound of tractor weight, *we do not increase the total cost* of the above three types of tractors (due to use of higher grade and lighter material) any more than 8, 12.8 and 14.5 cents respectively, then it is advisable to save as much weight as possible from an economical point of view.

The above takes into consideration the relation between weight of tractor and fuel consumption, which is the main, but not the only, item affected by the weight of a tractor.

The above figures are not of final reliability, but I give them in order to illustrate my proposed method of attack and to emphasize how important it is to have experiments conducted along this line and made public property.

FEWER PAPERS AND MORE DISCUSSION

(Discussion contributed after adjournment)

L. J. MONAHAN:—The meeting brought out the fact that not over one or two papers at the most should be permitted for an afternoon, and more complete discus-

sion should be encouraged. The trend of the papers because of practically no discussion was toward the four-wheel, two-rear-drive-wheel type.

Other types not referred to at all are running the four-wheel a hard pace in the market. The two-drive-unit track-layer is gaining in popularity and the two-wheel universal type has developed a large market.

The business is not in shape as yet to consider standardization of one universal type. At the same time, a short discussion by a majority of the members present would aid in establishing a composite of opinions which in turn would show the drift the engineering aspect might be expected to take.

It would seem that a general engine type with standard mountings could be settled upon, as well as a final drive, also a standard transmission mounting applicable to the four-wheel, two-drive-wheel, and two-drive track-laying type. It is beginning to look as though the track-laying type could be easily standardized in the simple two-track-drive without any separate front support. The four-wheel type can easily be standardized and the two-wheel type shows a development which would not appear to require radical changes in the future, so there is no reason why it could not be standardized as a type. The vertical multiple-cylinder or opposed double-cylinder engine for this type, however, is unsettled.

Fundamentals of Tractor Engine Design

By H. C. Buffington* (*Member of the Society*)

Chicago Tractor Meeting Paper

THE subject of tractor engine design seems simple at first thought, and immediately the general outline of a four or six-cylinder engine flashes through one's mind. We picture a smooth iron-clad masterpiece solidly mounted upon the frame of a "racy" looking tractor. We do not at first consider the carbureter, magneto and the other contrivances necessary to make it run.

Presently we ask ourselves, What are the essentials of a successful tractor engine; what have we gathered from actual experience, and not from theory? What the author has in mind is not an engine of high speed and light construction, nor is it a heavy one or two-cylinder engine; it is a four-cylinder one with certain elements of construction, which from experience have proved their worth. These elements of vital importance are the ones upon which the author will dwell.

Crankshaft.—This is the essential element around which the engine is constructed and therefore deserves first consideration. Too often this part has been neglected in the fight for lightness and cheapness. Personally the author prefers the three-bearing shaft. There are, however, some points in favor of the two-bearing type, in that the two center cylinders can be placed more closely together. Doing away with one bearing is an advantage, but on the other hand a heavy shaft is necessary and generally speaking the three-bearing type is best suited for large engines.

The crankshaft stress should not exceed 12,000 lb. per sq. in. for a 300-lb. per sq. in. explosion pressure. This will give a good solid shaft free from the vibration so destructive to bearings.

Crankpin Bearings.—A good proportion for the crankpin bearings is to take 57 per cent of the cylinder diameter for the pin diameter and 1.2 of the resulting diameter for the length. This will give a projected bearing area of half the cylinder area, thus keeping the pressure down to 600 lb. per sq. in., using the 300-lb. explosion pressure. The main-bearing stress, starting from the front end, should not exceed 400 lb. per sq. in., 400 lb. for the center and 250 lb. for the rear, taking the centers of the bearings as the points of reaction. The rear bearing pressure is low, but this is necessary to take care of the extra pressure caused by the transmission shaft if it happens to be out of line with the engine, which is often the case.

Removable Head.—Whether the cylinders should be of the L-head or valve-in-the-head type is a matter of choice. Those who prefer the L-head perhaps use it because, as I heard it expressed, "it is a good old family horse." On the other hand, the valve-in-the-head is chosen by the more particular, who do not want to be outdone on points of efficiency. The cylinder head should part in line with, or a little below, the top of the piston and not above, as the latter method makes it hard to clean; and the piston cannot be removed without first removing the carbon from the cylinder walls. There are several important reasons why the removable head should be classed as essential, for example, the possibility of cleaning carbon, grinding valves, doing away with the troublesome valve-cover plug, or valve cage, and making it possible to adjust the compression for high altitude. Figs. 1, 2, 3 and 4 show this difference and also illustrate how the adjustments for different compressions can be taken care of much more easily. Many tractors are working in altitudes as high as 8000 ft. and the changing of the head is a simple matter as compared with the changing of pistons.

Water Jackets.—The water space around the head should be liberal, as, unlike the automobile engine, a maximum load must be expected for a period of hours.

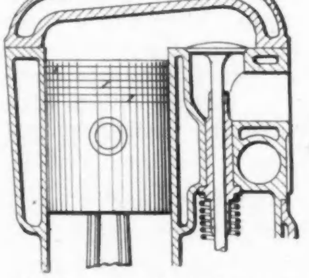


Fig. 1 — L-Head Cylinder with Head Parting Plane Above Piston Face

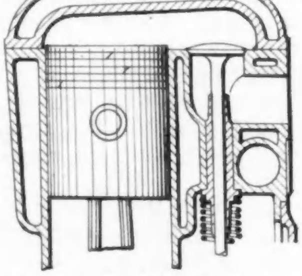


Fig. 2 — L-Head Cylinder with Head Parting Plane Slightly Below Piston Face

An even thickness of combustion-chamber walls is essential for the same reason, and means for checking up the thickness should be seriously considered. If, for instance, there be a hot spot in one cylinder, the carbureter must be adjusted for that, or the result will be disastrous, causing either preignition in one cylinder or excessive fuel leakage past the other three pistons.

*Motor Engineer, Minneapolis Steel & Machinery Co.

Long Stroke Preferable.—Theoretically, a tractor engine should not be pulled down below normal speed, but this is often done; in fact, at least 50 per cent of the time the operator will have his engine overloaded. For this reason the stroke should be at least 1.4 times the cylinder bore. The long-stroke engine is also desirable, because the difference between the engine speed and final drive is not so great, and it is more convenient in minimizing the transmission-gear diameters.

Flywheel.—The transmission itself has a great deal to do with the necessity for flywheel capacity, and the higher the efficiency of the transmission, the greater should be the increase in the flywheel energy. The less efficient transmission acts as a shock absorber and lessens the shock on the crankpins, while on the other hand the shock is transmitted almost directly to the crankshaft.

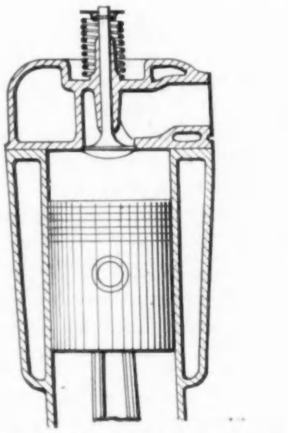


FIG. 3—VALVE-IN-HEAD CYLINDER WITH HEAD PARTING PLANE ABOVE PISTON FACE

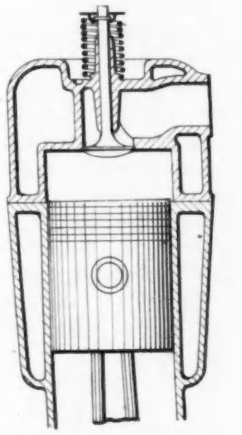


FIG. 4—VALVE-IN-HEAD CYLINDER, HEAD-PARTING PLANE SLIGHTLY BELOW PISTON FACE

It can then readily be seen why some engines with small flywheels do not have half a chance to stand up. In calculating the flywheel dimensions, double the horsepower should be taken with an allowance of 10 per cent variation in speed.

Speed Governing.—The control on the engine should be such as to limit the speed to about 10 per cent above normal.

Engine Rating for Kerosene.—This should be based on 800 ft. per min. piston speed, and should not be over 75 per cent of the engine's maximum capacity in gasoline. Actual laboratory tests have shown that the power output on kerosene is within 8 per cent of that on gasoline, but this cannot be expected under actual working conditions.

Fuel Economy.—When pulling its rated load before leaving the test block a tractor engine should not use more than one pint of kerosene per horsepower-hour. This fuel should have a gravity not lower than 42 deg. Baumé, and an open flashpoint of not over 120 deg. fahr.

Engine builders today are at a disadvantage in not having a standard fuel with which to develop their product. I suggest that the Society establish a standard kerosene and a standard gasoline.

Manifold Heat-Control Essential.—One reason why it is difficult to run tractors successfully on kerosene in the country is on account of the grade of kerosene used in small towns. This kerosene might be termed lamp oil, and although the specific gravity is not so low, the open flashpoint is very high. In order to vaporize this fuel for use in engines, it must be heated to a very high temperature, which, of course, reduces the power output. This fuel gives a very good light, and there is no danger from its exploding, but it costs more than the so-called distillate, which in most cases is an excellent fuel.

This point pertaining to difference in fuels is mentioned to point out the necessity of controlling the heat between the carbureter and cylinders.

When it is necessary to use water with the fuel, the control of the former should be automatic, because it is our experience that the farmer has had considerable trouble during the first few weeks of use of engines not having automatic control of water.

Spark-Plug Location.—The author has often been advised as to the proper location of the spark-plug, but after many experiments and sad experiences, has proved that the trouble in securing such a location is due largely to lubrication.

Without doubt fifty per cent of magneto troubles will be cured by properly locating the spark-plugs, and yet engines are designed without attempting to determine this. Without hesitation the designer will place it over the intake valve on an L-head engine or on the intake side of the valve-in-the-head type. Spark-plugs should not be placed near the line of the cylinder bore, where oil from the piston will splash on the plug (see Fig. 5), nor in line with the intake gases when using kerosene as fuel. A careless operator will use either too much fuel or too much water with the fuel, and improper ignition will result when the plug is directly in the path of the gas flow.

The direction of the crankshaft rotation will sometimes make it necessary to shift the plug to the opposite side, because the excessive oil (Fig. 5) thrown from the crankshaft will always lodge on one side of the cylinder. If the plug is on this side or in line with this side, it will become fouled much more quickly. The location over or near the exhaust valve has often been criticized, but aside from the fact that the spark-plug itself will have to be replaced more often, it is the most reliable position.

Lubrication.—The tractor engine furnishes the hardest lubrication problem in engine design at present, and will continue to do so until a better method of using kerosene as fuel is employed. A most excellent oiling system has been developed for the automobile, but it has turned out to be a miserable failure when used with kerosene under actual working conditions in the field.

We dislike to throw away lubricating oil, and every effort should be made to prevent such loss. It is cheaper, however, to use the lubricant only once, and then to let it drain from the crankcase, than to cause the deterioration of the engine by too great economy of oil. Time is lost in making adjustments and repairs caused by the used-over oil as it gradually becomes thinned by the fuel passing the pistons. The most reliable method of lubrication is to force fresh oil to each moving part, crankpin bearing, main and camshaft bearings, gears and cylinders, and drain it into a reservoir from which it is drawn from time to time.

Every care should be taken to clean the air drawn through the carbureter and breather. The oil supplied the crankpin must pass through a drilled hole, so that any dust entering the crankcase will gradually pack and clog the passages. Any other method, whether force or splash, in which oil is used twice, will cause rapid wear. This is not the case with carefully operated engines, but we cannot expect unusual care from the average operator.

Accessibility.—Handholes placed in the side of the crankcase, so that the bearings can be inspected, are quite necessary and the base-pan should be light and easily removable. Every effort should be made so that wearing

parts can be removed easily and to avoid crowding small nuts into corners and out-of-the-way places.

Engine Mounting.—In conclusion, I wish to say a word about mounting to the tractor designer; this may not relate to the essentials of engine design, but is necessary to the success of its operation.

Every effort should be made to have the engine accessible, not only on the carbureter side but on all sides, especially to allow clearance underneath. Allow plenty of room for removing the base-pan; if possible avoid fastening tractor parts to cap screws and nuts used in fastening engine parts, especially to the cylinder-head bolts; this only tends to discourage the operator in making necessary adjustments.

I cannot lay too much stress upon the importance of having a flexibile connection between the engine and the transmission drive-shaft. It has been necessary to provide extra large bearings at the flywheel and to take care of the vibration caused by the transmission and engine shaft being out of line, but this destructive feature can be remedied. I suggest that a self-contained clutch be mounted upon a stub shaft bolted to the flywheel flange bolts, and also that a flexible coupling placed between the clutch and transmission. This construction, Fig. 6, not only takes the extra pressure off the crankshaft, but also allows the transmission bearing to run freely.

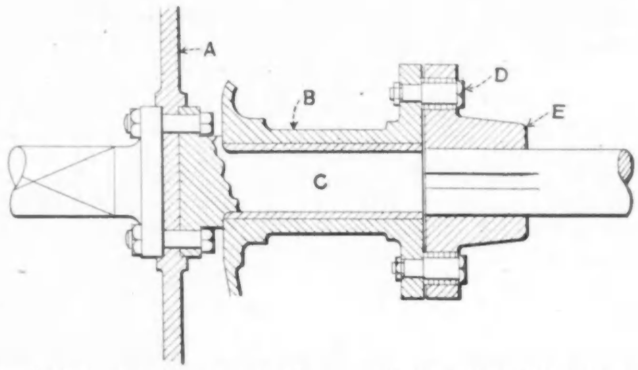


FIG. 6—FLEXIBLE CONNECTION BETWEEN ENGINE AND TRANSMISSION
A—Flywheel, B—Clutch-Driving Spider, C—Stub Shaft Extension, D—Flexible Driving Pine, E—Flange of Transmission Shaft

THE DISCUSSION

R. E. DAVIS:—The old type of heavy tractor has the fault of being open and too many places require attention. By that I refer to the valves which are open subject to a shower of dust under the average field working conditions. This shortens the life greatly, far more than one might expect. On the other hand, the average automobile type of tractor engine, as we might call it, is inclined to be too "skimpy" in the bearings, and as the paper just read brought out, sufficient attention is not given to lubrication. If we could combine the idea of large bearings and inclosed construction to keep out dirt, maintaining a generous film of oil, it would prolong the life of the old tractor anywhere from three to five years; this applies especially to the valves, which are vital parts of the tractor and is particularly true of the horizontal valve which tends to rub continually against one side of the stem guide and chafe against the seat at every stroke.

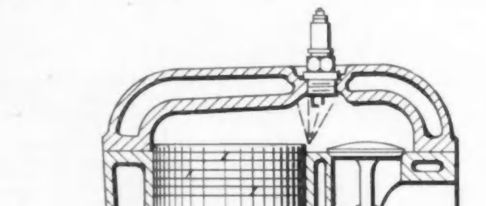


FIG. 5—UNSATISFACTORY LOCATION OF SPARK-PLUG WHERE IT IS SUBJECT TO IMPINGEMENT OF LUBRICANT

THE FUEL PROBLEM

THOMAS J. LITLE:—I believe the biggest problem today in tractor engine design is the fuel problem. We are trying to use kerosene in gasoline engines and are not succeeding very well because we hear of the dilution of crankcase oil and consequent destruction of the bearings. When we try to use kerosene in the old-type gasoline engine, and send fuel into the intake passages in the form of a rainstorm, a great deal of it drops out, much of all that gets into the cylinders never burns but merely wets the cylinder walls and is forced down by the rings, so the real fuel problem is to gasify or vaporize the fuel before using it. Not only kerosene, but a great many other fuels are going to be used after this war. I have been spending all my time for the last two months investigating this very problem. Alcohol and benzol and mixtures of the two, and a good many other engine fuels will be employed, but the engine designer must not leave it all to the carbureter manufacturer. He must bear this in mind and avoid abrupt turns in the intake passages because the fuel cannot be sent around too many corners.

J. C. SLONNEGER:—The company I am with has not yet attempted to solve the kerosene problem, and I am not in position to speak about the kerosene problem, but it occurs to me that as yet a really successful tractor engine has not been built to burn even gasoline, and we are merely adding to our troubles in attempting to burn kerosene. I am sure that if the manufacturers of tractors would try to solve the problem of burning gasoline satisfactorily, and go after it with as much energy as they have after kerosene, we would have a much better tractor engine today.

ENCOURAGING ALCOHOL MANUFACTURE
(Discussion contributed after adjournment)

G. L. LEWIS:—The war is bringing us face to face with the problem that might have been held off for another generation. But the enormous demand for fuel oils

has increased by leaps and bounds, until it is reported there will be a shortage of over 1,300,000 bbl. this year. It is also reported that the Standard Oil Company took out of its reserve over 830,000 gal. of gasoline last year.

In the development of our internal-combustion engine the minutest details have been gone into microscopically, so to speak, and with the greatest amount of criticism, that we might make as nearly a perfect engine as possible. Yet we have considered the fuel supply only indifferently, or only as it was forced upon us. We have scarcely concerned ourselves about the source of supply or permanency of the supply. When some far-seeing mind attempted to bring up legislation whereby a substitute could be manufactured a strong lobby immediately set to work to defeat the measure.

The time is opportune and ripe for the Society of Automotive Engineers to turn its attention to alcohol legislation. I think it is our patriotic duty to assist in forcing Congress to pay heed to the needs of the people. Now is the time to enact laws authorizing the manufacture of alcohols so that relief from the high cost of fuel can be had in the home as well as in the engine industry.

The world is in a critical condition, and we should develop our artificial as well as our natural resources, for which we have an unlimited supply of raw material. There is scarcely a house that does not throw away enough raw material to heat, light and cook with if proper legislation were enacted. Convert our garbage plants into alcohol stills, and the utilization of this now waste material would be worth millions to our nation.

MECHANICS FOR WAR SERVICE

STATISTICS gathered by the National Advisory Committee for Aeronautics from the records of the Signal Corps of the War Department show that this branch of the service is well organized to supply the requisite number of repairmen to keep our aerial fleet in action, after it gets well started. There will be no shortage of airplane mechanics.

Effort is made to secure airplane mechanics from voluntary enlistment, induction, draft, and selection from the National Army and National Guard. Men so obtained are trade-tested at the place of mobilization and organized into squadrons. Any trade list which is found short is filled by training men who have the necessary qualifications.

Airplane mechanics are formed into Service, Supply, Repair, and Construction squadrons of 150 men each, of various trades, and these squadrons are given intensive training eight hours per day for 30 days, after which each squadron is ready for active service as a complete unit.

Under this plan thousands of enlisted men are now in training at various schools and manufacturing establishments. This work is being constantly enlarged.

Motor Truck Service

Engine mechanics for the four Motor Mechanic Regiments now being organized at Camp Hancock, Augusta, Ga., have been and are being secured through a system of selection from National Guard and National Army, and men of the required qualifications already enlisted in the aviation service.

Balloon Service

The balloon service is able to secure practically all of the trades required in enlisted men by selection from aviation recruits. The necessary training to make these men work as a team is given to them at the various balloon schools.

Tractor Transmissions

By E. R. Greer* (*Member of the Society*)

Chicago Tractor Meeting Paper *Illustrated with* Photographs and Charts

When we speak of a tractor transmission, we generally mean the entire power-transmitting device, from the engine to the ground, including the pulley for belt work. Tractor transmissions are still in an early stage of development. They are composed of a number of groups of parts that are arranged differently in nearly every case, so that they cannot be classified without dividing them or making a special class for nearly every tractor now being manufactured.

There are differences of opinion among tractor engineers regarding many of the most vitally important features of tractor transmissions. Some believe in rough open gearing and large plain bearings, as opposed to those who insist on cut hardened inclosed gears and anti-friction bearings.

The question of wheels for traction vs. track-layers is far from settled. The right size of wheels for wheel tractors seems to be further from being agreed upon than anything else, and it is one of the most fundamentally important things in tractor design. The design of a tractor transmission is affected greatly by the design of the wheels or tracklayers that are to give the traction. The matter of traction is of first importance to the successful tractor, and it is here that opinions differ widely.

*Assistant Superintendent, Emerson-Brantingham Company.

The track-layer with its large surface contact has an advantage on marsh land or sand, where the top soil is tougher than the ground beneath, but is at a disadvantage when just after a rain the ground is muddy on top and harder below. It can bridge a small ditch but becomes blocked by one too large to bridge, and side hills or side draft cannot be taken care of as efficiently as when wheels are used.

Wheels, simple and not expensive, must be of sufficient size and provided with lugs to give good traction. If a tractor wheel once starts to dig it will not climb out of its hole unless the load is released. On smooth hard ground a small wheel gives efficient traction, but on newly plowed sandy soil or on land where there are washed-out ditches a large wheel must be used. The matter of lugs is of utmost importance. On some kinds of ground a spiral cleat at about a 45-deg. angle will give double the tractive effort that can be obtained from the same wheels with straight cleats or spikes.

For efficient general farm work with wheel tractors of from 8 to 15 drawbar hp., the drive wheels must be 5 ft. in diameter or more, and the problem of the best way to drive the wheel is important. The effort being applied to the ground, it follows that the rim is the natural place to apply the power, but the rim runs in the dirt, so that it is necessary to apply it at some point far enough from

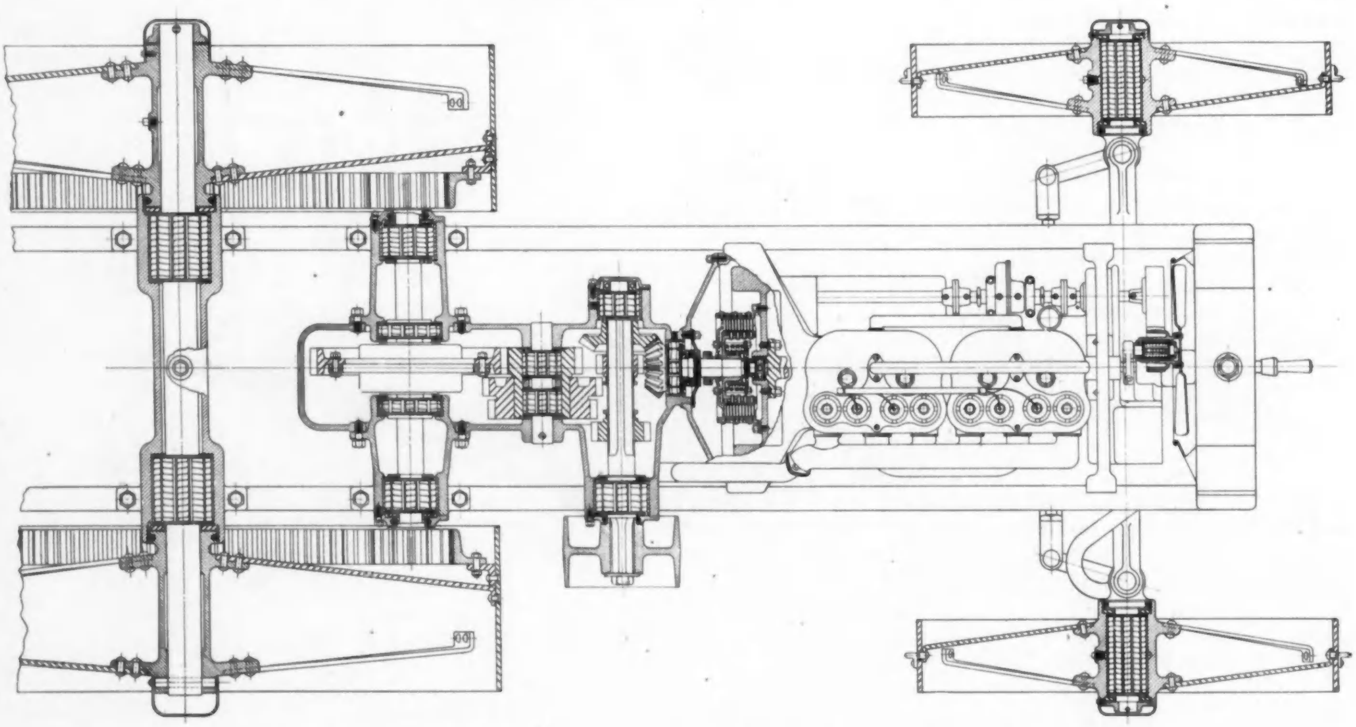


Fig. 1—Hyatt Roller Bearing Company's Conventional Tractor Bearing Layout

the rim to be protected from the dirt. If the drive is carried to the axle the torsional strains become severe, and good construction is expensive and difficult. From all indications the inclosed internal-gear drive is likely to become the standard traction-wheel drive.

The next important item is the location of the drive-pinion. The one best location is a point forward and a little below the wheel axle. When the pinion is in this location the driving force is carried directly to the ground, so that the load on the drive-wheel axle bearings due to the power delivered is opposite to the load due to weight, and the amount of load is the difference between the driving effort delivered by the drive pinions and the weight of the tractor that is supported by the axle when the tractor is standing. In other words, the drive-axle bearings are practically floating when the tractor is pulling a certain load. At less load the bearing pressure is downward and at greater load the pressure is upward. The strain of the drawbar pull is carried by the drive-pinion bearings through the pinion teeth to the drive-wheel rim and the ground. It is the lifting effect on the front end of the tractor that results in its forward movement. A number of tractors have enough power to

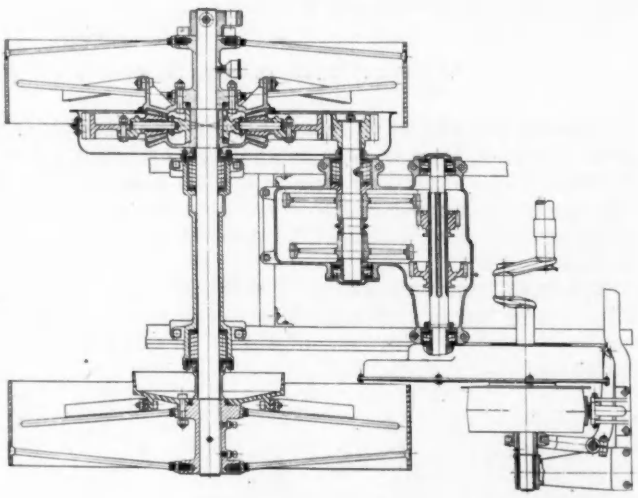


FIG. 2—TRANSMISSION AND TOP DRIVE OF CASE 9-18 TRACTOR

raise the front end clear of the ground so that the front-end weight is the limit of their pulling power. These tractors are difficult to guide and are of no use at all on hills. Enough dead weight must be carried on the steering wheels so that the tractor can be guided on the steepest hill.

The front-wheel drive offers an easy solution for hilly

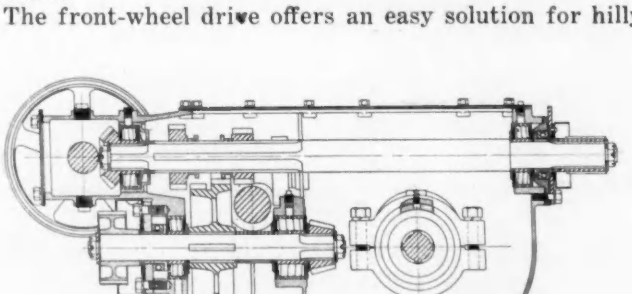


FIG. 3—VERTICAL SECTION THROUGH EMERSON-BRANTINGHAM TRANSMISSION

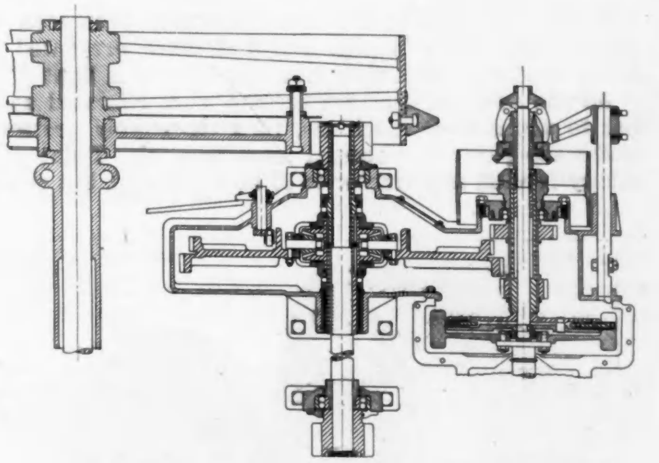


FIG. 4—PARRETT CLUTCH TRANSMISSION AND DRIVE

ground as in this case the reaction from the load is downward on the rear steering wheels. There is no tendency to tip up, and the harder the pull the more positive is the control. The rear wheels must be of ample size to carry the additional load, and the difficulty is in arriving at an arrangement to handle the implements when the front wheels are the drivers. While the steering mechanism may be complicated, the power transmission can be simple, the weight can be placed mostly on the drive-wheels, and ditches and hills can be easily negotiated. The four-wheel drive immediately suggests itself, but the mechanical complication and expensive construction make it prohibitive.

The protection of the working parts is not easily accomplished in tractor transmissions. An argument used by those who favor open rough cast gearing is that the farmers cannot keep transmission grease or oil clean and that some grit is always put into the case at every filling. They make the claim that as long as parts cannot be kept clean they wear out and may as well be made simple, open, and to operate without lubrication or when covered with dirt.

One unprotected drive, known as the roller pinion drive, has been extremely successful on tractors. It can be made to last a season, is cheap, and is easily replaced. Perhaps the worm-drive gear can be taken as the oppo-

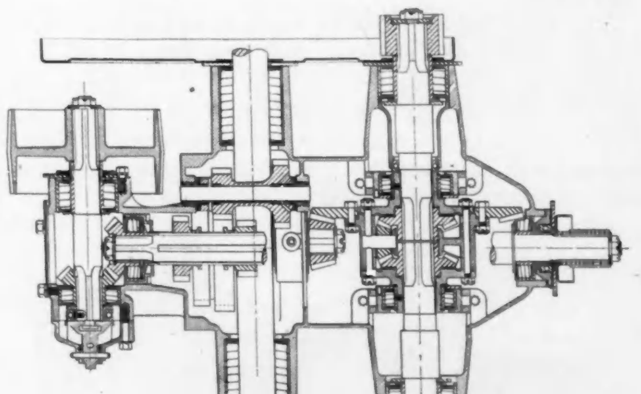


FIG. 5—HORIZONTAL SECTION THROUGH EMERSON-BRANTINGHAM 12-20 TRANSMISSION

site extreme because the excessive tooth pressures, together with the vibration and dirt, have prevented its being a success, no matter how carefully it is built.

As the users of tractors become more educated so as not to abuse their machines, then thoroughly protected well-made parts will become more general. Today simplicity is vital if a tractor is to be successful, but education is increasing the demand for well-made, efficient, protected parts.

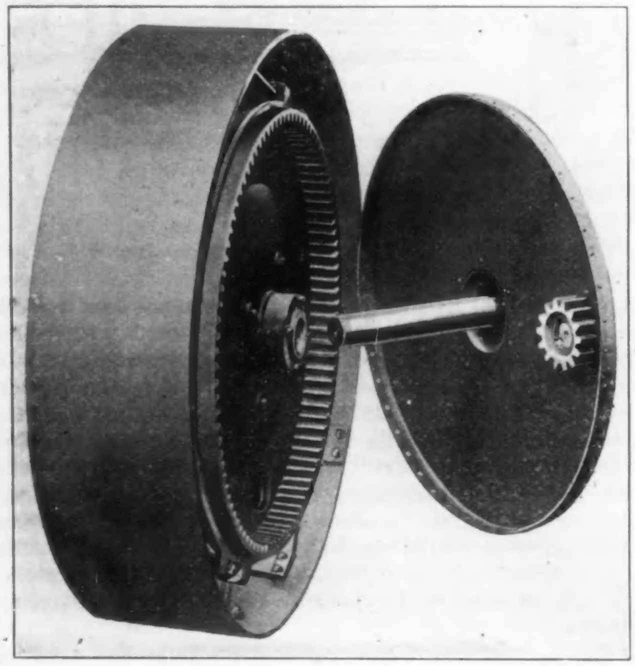


FIG. 6—MINNEAPOLIS STEEL AND MACHINERY COMPANY'S INTERNAL GEAR FINAL DRIVE

Anti-Friction Bearings

A notable advance in tractor transmission design is that anti-friction bearings are becoming universally used. It has been found that an ample, non-adjustable, anti-friction bearing can last indefinitely in tractor service. Transmission-bearing trouble has been a common tractor fault in the past, and its elimination is a decided step ahead.

The shafting as a rule is made of ordinary mild steel, because gears and bearings generally have to be of such a size that the shaft sizes are ample when this material is used. It is important that splines be used instead of keys.

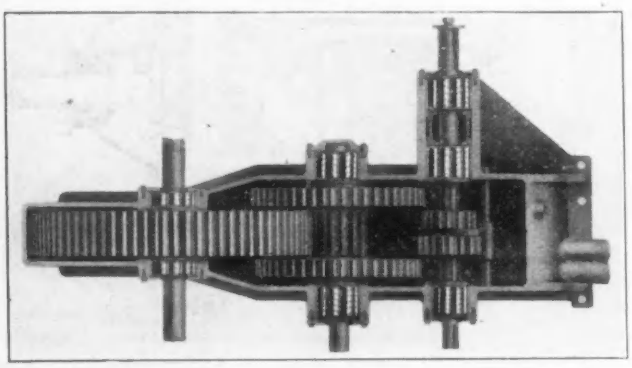


FIG. 7—TRANSMISSION OF THE GRAY TRACTOR

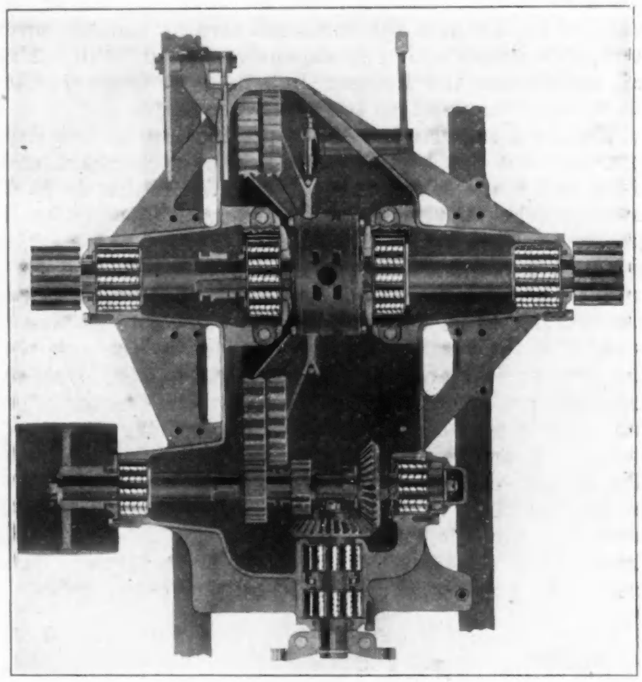


FIG. 8—"BIG FOUR" 20-35 TRACTOR TRANSMISSION

The standard type of automobile or truck transmission does not meet tractor requirements at all. The gear reduction is too small, no belt pulley is provided for, the change-speed arrangement is wrong, the parts are not large enough, and it cannot be applied to a good tractor design.

The total gear reduction in a tractor varies between 30 to 1 and 100 to 1, so that several reductions have to be used, although in some cases entire transmissions are built as a single unit. It is best to discuss each reduction separately, and to consider especially the final reduction by itself.

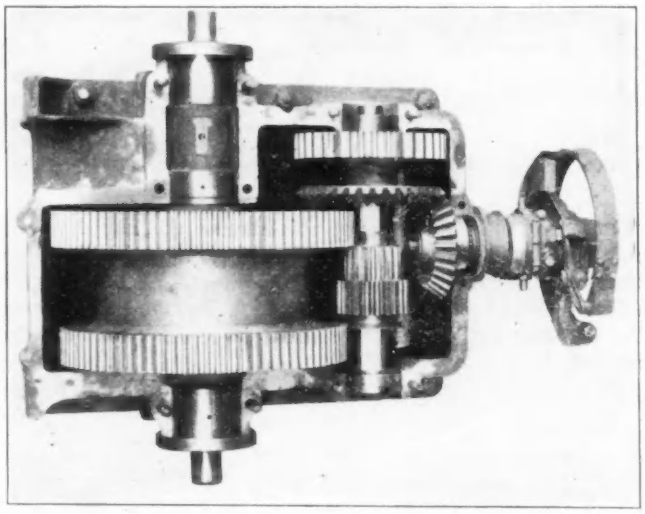


FIG. 9—MINNEAPOLIS STEEL & MACHINERY COMPANY'S CLUTCH AND TRANSMISSION

In general all tractor transmissions are driven from the engine through a friction clutch. No universal-joints are used, although clutches are designed to take care of any misalignment. Cone, disk, shoe, band clutches, and

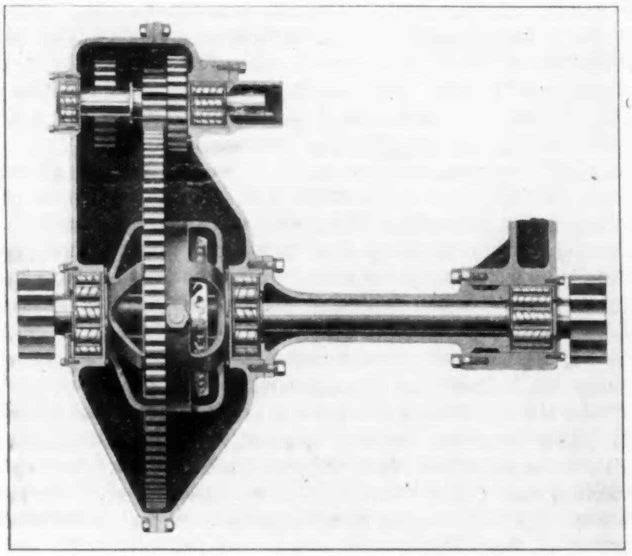


FIG. 10—MOLINE-UNIVERSAL TRANSMISSION

friction drives are in use. The cone clutch and the internal expanding shoe clutch are most common.

First Reduction Gearing

First-reduction gearing may be of almost any kind. The reduction varies from 1 to 1 to as much as 8 to 1. The change in speeds and the reverse are often worked in on the first reduction, but it is also common to use the second reduction. When the engine shaft is not parallel to the drive-wheel axis the first reduction gears are often of the bevel type. There is considerable advantage in having the bevel gears as the highest speed gears. The cost is reduced and also a chance provided to get a belt pulley on a fairly high-speed shaft without the necessity of using a separate set of gears and a clutch.

When spur gears are used for the first reduction, the change-speed gears and reverse are generally a part of it as they can be much smaller and cheaper in this position than in the next reduction. This arrangement is general on tractors, in which the engine sets crosswise; it is also used to some extent when the engine shafts are set lengthwise of the tractor, even though this arrangement necessitates a larger and more expensive set of bevel gears in the second reduction and also the use of a separate set of gears for the belt pulley.

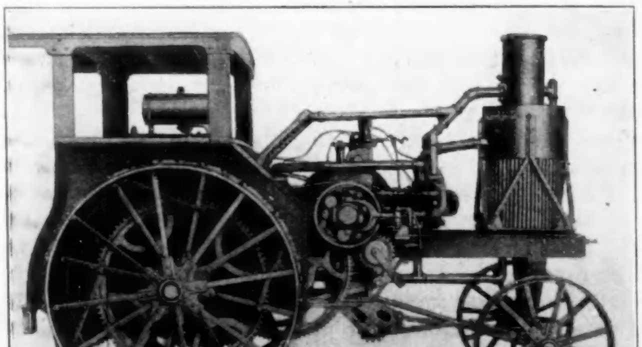


FIG. 11—AVERY TRACTOR, SHOWING LARGE EXPOSED TRANSMISSION GEARS

Change-speed gears are usually arranged so that the pinions slide on the drive-shaft and engage large gears on the driven shaft. No divided shafts or countershafts, as are found in automobile transmissions, are used, except for reverse gears. Thus all gears are disengaged, except the ones actually in use, and no idle gears or extra reductions are necessary for different speeds.

Another advantage in this arrangement is that all change-speed gears are disengaged when the belt pulley is to be used. Tractors are used for belt work for long continuous runs and gears or shafting running idle

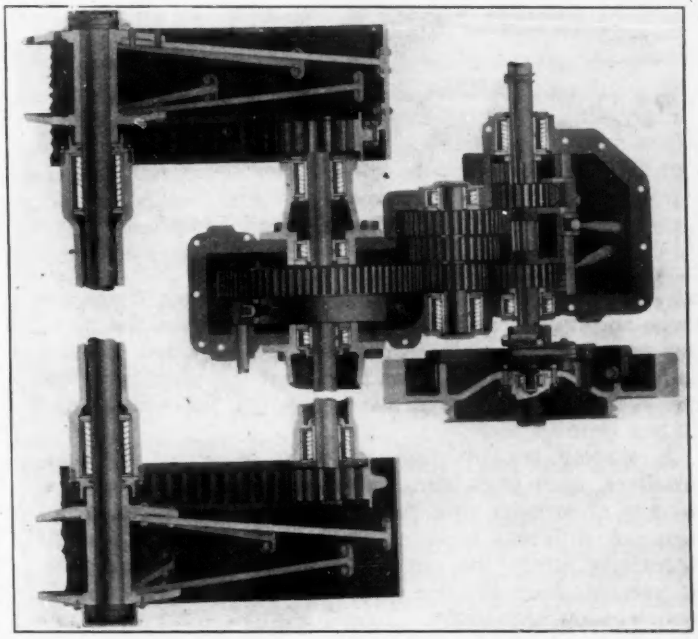


FIG. 13—TRANSMISSION AND INTERNAL GEAR DRIVE OF THE WATERLOO BOY TRACTOR

are undesirable because they waste power and require special lubrication.

Second Reduction Gearing

The second reduction is sometimes the final drive, although this is not often the case. Usually it is the drive to the shaft that carries the differential. If the differential can be placed in this position ahead of the last reduction considerable expense can be saved because all the parts can be made much smaller.

Differentials have to be made strong and of ample size, because the traction members are always slipping, so that the differential parts are working all the time. Differential locks are considered good practice. Brakes for holding one side for short turning are often used, but brakes for stopping, while necessary, are not important.

Third Reduction Gearing

The third is usually the final reduction; it is the most important part of a tractor transmission. The load and vibration on the teeth and bearings generally cause wear of these parts first, and as they are large, expensive, and difficult to replace it is necessary they be made to give the best of service.

When there are more than three gear reductions, the extra one is used either to gain compactness or to provide for some special arrangement of parts.

Tractors are used for plowing a large part of the time and generally are operated at speeds of from 2 to 2¾

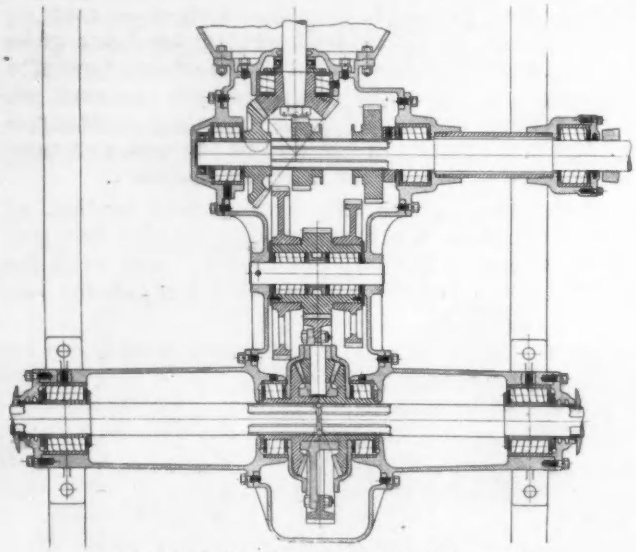


FIG. 12—R. D. NUTTALL CO. TRANSMISSION

m.p.h. Many have only a single speed, but most of the late designs have two or three speeds. When there are three speeds one is lower and one higher than the plowing speed. When only two speeds are provided the second speed is usually slower than that for plowing. The range between speeds is nearly always between 30 and 40 per cent.

A tractor transmission is really a series of compromises, each part being affected by all of the others, so it is no wonder that there is such a difference in design. A different location of the belt pulley alone will materially affect the entire transmission arrangement. At present there is little chance of formulating valuable transmission standards. It will require more time and many tests to prove what is best.

THE DISCUSSION

CHARLES A. TRASK:—Thousands of tractors with friction transmissions are in successful operation, and I feel that this type is entitled to more than passing mention, in view of the complete information given by Mr. Greer covering various forms of gear transmissions.

E. R. GREER:—I was not able to obtain any illustrations showing tractors with friction transmissions, which is the reason why they are not covered in my paper.

ANTI-FRICTION BEARINGS FOR TRACTORS

(Contributed after adjournment)

R. E. DAVIS:—The majority of the illustrations in Mr. Greer's paper show anti-friction bearings. This shows the trend of thought to be in favor of fuel economy, which is very fitting at this critical time in our nation's history. The question of economy on drawbar work is of great importance, not only to the user but to the entire world. The amount of power loss in an anti-friction bearing is only a very small fraction of the power loss in a plain bearing. The loss in a plain bearing is from 10 to 20 times greater than the loss in an anti-friction bearing, according to available information and tests.

Taking the smaller figure, and giving the plain bearing the benefit of the most favorable conditions, the difference in power loss is still great enough to warrant our careful attention. It is great enough on a tractor of 20 b.hp. to increase the drawbar capacity and efficiency 40 to 60 per cent over the capacity and efficiency with plain bearings, all other things being equal.

At once the question comes up, "the engine has power enough to slip the wheels with plain bearings, therefore no capacity is gained by the added saving in power." In many cases this is true, but it merely proves that the design is not properly balanced to take advantage of the engine's power when anti-friction bearings are substituted. This condition could easily be adjusted to take advantage of the increased drawbar power of 40 to 60 per cent, still reserving enough to slip the wheels.

Where the old rating for such a sized tractor was 10-20, with plain bearings in the transmission and axle, the tractor's rating could be 15-20 for anti-friction bearings. Of still greater importance is the question of drawbar economy. Again taking the 20 b.hp. tractor, previously referred to, the difference in power loss between plain and anti-friction bearings amounts to 5.38 hp. at full load. The plain bearing losses are distributed as follows, based on 10-20 rating:

	Drawbar Per Cent
2—Bearing next to bull pinions	19.5
1—Bearing on first reduction shaft nearest overhanging gear	15.5
1—Bearing on opposite end of first reduction shaft	5.5
1—Bearing on counter shaft	5.5
1—Bearing on counter shaft	5.5
2—Rear axle bearings	4.2
Plain bearing loss	55.7
Anti-friction bearing loss	1.85
Saving in favor of anti-friction bearings	*53.85

* = 5.38 hp.

This amount is clear gain, and can be added directly to the drawbar and given credit as a net saving. In other words, a 20-hp. engine working at full load will deliver to the drawbar a little over 50 per cent more net power with anti-friction bearings in eight of the ten places than it would do if plain bearings were used. This means a saving of a little over 50 per cent of the fuel required to do the same amount of drawbar work, or approximately 10 gal. of fuel per day's work of the plain-bearing type tractor when under full load.

In this particular size tractor the additional cost of the anti-friction bearings, to cause the above saving, amounted to approximately $30.00 per tractor at the present market prices. This cost would be regained in fuel saving within a very few days.

There are a very few, if any, of us today who would design an automobile or truck with plain bearings throughout the transmission and rear axle; much less would we think of putting a grease cup on each of these bearings and asking the user to crawl under and tighten these cups each hour.

When the fuel-saving and trouble-saving problems are presented to the prospective purchaser of a tractor it would be an easy matter for the worthy customer to decide whether or not he wants to pay 2 or 3 per cent more for a tractor that would save 50 per cent of his fuel on drawbar work and at the same time require lubrication once a week instead of once an hour; and in addition to all these advantages give him an opportunity to do his bit in conserving the world's gasoline supply.

Farmers' Service Requirements

By George Cormack* (*Member of the Society*) Chicago Tractor Meeting Paper

SERVICE as generally accepted is something that the tractor manufacturer has to give to the buyer of a tractor after the salesman has told the buyer that he will never need it. It will be noticed that I used the words "as generally accepted." Again, service in the tractor industry is assumed to be a function pertaining solely to the sales department, and to all of the agencies interested in selling the goods. To my way of thinking service in the tractor business is much more complex than simply fixing the farmer's tractor when it balks and teaching him how to run it, although these are doubtless important and too much intelligent attention cannot be given them.

No matter how efficient a corps of tractor salesmen and trained tractor experts are, or how prompt the service to the customer in times of trouble may be, troubles will only increase and multiply as the business grows unless the system of service reaches much further back into the organization than to the sales department and the efficient army of trouble shooters. Service, real service to the customer must begin long before the customer becomes a vital element in the success of the business. Service to the customer begins in the engineering department and in the drafting room, in close conjunction with the experimental department. From the first line put on a piece of drawing paper by the designer down through the endless processes of production until the finished machine is handed to the buyer, service to the buyer should pervade and dominate every activity, every movement.

Service Means Usefulness

The maximum usefulness of a tractor can be obtained only by the intelligent cooperation of four human elements all working to attain maximum efficiency with minimum effort. These four are: The designer, the manufacturer, the sales department, and lastly the farmer himself. As yet the tractor problem is not a sales problem, anything on four wheels that can move around for a short time can be sold as a tractor. The problem so far is purely one of design and manufacture. Some day in the future when the designers have produced better machines and the manufacturers have built them just as well as they know how, then will there be many first class tractors on the market, then and not till then will it change to a real sales problem.

In a majority of our engineering departments we have too much invention and too little sane machine design, too much guess work, too little thorough investigation and scientific research, too much of taking a gambler's chance, and thinking we can thus succeed; and too vague a realization of the extreme difficulties of the problem we are trying to solve.

Every designer of machinery, if he is really efficient, is more or less of a pessimist regarding his own products. He cannot escape knowing the many intricate and vexing problems yet to be solved, he knows that there never was and never will be a perfect machine, and that the most he can do is to eradicate some of the faults and weaknesses. The mind of the real designer—I am not talking of inventors—is continually focused on these weaknesses and faults and in consequence he looks at his product from a standpoint absolutely opposed to that of the good salesman, who believes without question of a doubt that the machine he is selling is the one and only perfect machine on the market.

Whenever we hear anyone who claims to be an engineer, a designer, telling what a wonderful machine he has designed, so much better than anything ever made before, we can make up our mind that he is not a real designer and never will be. It is quite possible for an experienced designer to design a machine more nearly perfect than anything ever before produced, but the man capable of that is not bragging about it.

No amount of field service, be it ever so efficiently performed, can compensate for the inefficiency and carelessness of the tractor designer. He owes it as a service to the customer to incorporate in his design such elements, and such only, as careful study, close observation, experience, and good judgment convince him are the best, not the cheapest. One of the principal features in tractor designing, and one that receives far too little study and attention, is accessibility of the parts that must have attention and adjustment. I use the words "must have"; ordinarily in our advertising matter we say "might need." Tractor design should in all cases call for first-class workmanship, and the designer does not radically depart from standard mechanical practices unless he has abundant opportunity and time to make thorough tests.

It is better to keep away from inventions that are going to revolutionize the industry and instead to stick through thick and thin to the evolution of a practical, sane design conforming in every way possible to such standards as have already been set, and to lend every encouragement and help within our power to further standardize tractor elements. The designer who is working along these lines is doing the first and greatest service possible to the farmer. Only by evolution in design and standardization in detail is it possible to make better and really cheaper tractors. Progress in any line of our activities is like the progress of the sun—so slow that we cannot see it, but so sure as the change from night to day.

Cause of Short Life

Many different makes of small tractors are now on the market, and what follows relates only to small gas tractors, four-plow and smaller. A large majority of the small tractors sold are practically wrecks at the end of one year's work. Some struggle through two years' service while a very few are still running at the end of three or four years. I have never seen a tractor that has been in continuous use for five years on the farm, although it is quite possible that such a machine can be found. It will be generally conceded, however strongly we may talk about the long life of tractors, that a tractor of this class that is still at work after ten years' continuous service is worthy of a place in a museum.

Why is it that our tractors cannot give at least seven

*Superintendent Tractor Department, Appleton Mfg. Company.

or eight years' service? Of course we very naturally say that the farmer does not give the tractor proper care; he overloads it, he uses the wrong kind of lubricating oil, he does not change the oil as often as he should, he does not keep the delicate parts clean, and other things that we blame onto the poor farmer. Very often all or part of these things unquestionably are true, but all farmers are not that way. Some that I know are careful and use the best of judgment; they are willing to follow any suggestion in order to keep their machines up to the point of highest efficiency. There is a steadily increasing number of really good tractor operators, but even they can use a tractor only for a few seasons. The main reason why gas tractors are so short-lived is because they are not carefully enough designed, and because they are in too many instances designed and manufactured, not with the idea of giving long and continuous service to the farmer, but solely to come inside a cost price that will allow an attractive selling price to be made to the customer. To my way of thinking, success in the tractor business will never be based on price alone; quality, durability, ease of operation, accessibility of parts, the elements that give and insure long and satisfactory service are the points that eventually will hold the attention of the farmer.

Cheapening Manufacture

We as a nation have a reputation for manufacturing many machines and other articles of high quality and merit; along with this we are known as the topnotchers in displaying ingenuity in our processes of manufacture. There is only one way to cheapen a first-class machine and that is through improved methods of manufacture. If we analyze the production methods of any company producing first-class machinery we will find that a hundred times the inventive genius necessary to design the product has been expended in the invention of jigs, tools and special appliances necessary in its economical production. The main difference between the ordinary inventor and the trained and experienced designer is that the inventor too often has no conception, and has a disregard of how the several parts of his machine are to be made; the designer, if efficient, sees every detail of the process through which every single piece must pass before it becomes a part of the finished machine. Real designing is restricted by the questions: How is the pattern to be made? Can it be molded easily? How is it to be machined? and will the jigs and tools necessary be too expensive?

On the other hand we also have a reputation for putting out much stuff that is pure junk, particularly in the way of tractor accessories. Take, for instance, the ordinary agricultural monkey wrench, which is sent out to the farmer by the millions, being given to him with almost every machine he buys. Ninety per cent of them are no good and can only be used a few times, if at all, and the farmer usually buys a good one himself. This holds good in regard to malleable wrenches and cheap pliers. The other day I saw a sample of pliers intended to be sent out with tractors and gas engines; they were imitations made of practically worthless cast iron. If we are going to send out wrenches and tools with our tractors, let us send good ones, something that can be used. It is better to send out a machine without tools than to send it out with cheap, worthless trash that we dignify by the name of the necessary tools.

Today too many tractors are simply imitations. Tractor designers, if they do their full duty to the farmer, must design for service and real lasting service only. It may be said that many farmers cannot afford to buy a high-grade tractor, but I say that the man who really has use for a tractor cannot afford to buy any other kind. From talks I have had with farmers who have bought cheap tractors, with the inevitable consequences, they are rapidly coming to look upon the tractor-buying problem from the quality-first standpoint. If the tractor manufacturer insists that his designers give him a carefully-thought out and practical machine, that it is built of the best materials, with such an equipment of machinery and men as will insure the best workmanship and interchangeability of parts, then and only then is he rendering the first and greatest service to the ultimate buyer, the farmer. All further services are secondary, however important they may seem to be.

Thoroughly trained and competent men should be sent out to instruct the customer as to the proper things to do, and also the things not to do. These men should also give a good deal of their time to instructing the dealer and his men. I do not believe that these instructors should be salesmen. Some salesmen make good service men, but usually the salesman has other things to think about; if he fails on a service job he naturally is hurting the reputation of the machine he sells, and what is worse from a sales standpoint, his confidence in the machine.

The greatest service that the salesman can render the tractor buyer is to tell him the truth, the whole truth, and nothing but the truth. He cannot do this, however, unless the designer and the manufacturer give him a machine that will stand all tests. The tractor salesman not only should be thoroughly versed in the merits of the machine he sells, but he also should know its limitations and should frankly tell the buyer about these limitations.

The farmer has one peculiarity in regard to any prime mover, be it gas engine or tractor. When it is first started up he has an insane desire to stall it, especially so if some one from the factory is around. Hundreds of gas engines and tractors, if not ruined, have had their period of useful service shortened by thoughtless foolishness in trying to make a spectacular start. Of course the farmer pays for all this, but if the salesman wants to be of real service to his customers he should use every argument he can to convince them that they will be working for their own best interest if they will use common sense and a little better judgment in starting the new machines they buy. If he can induce the farmer who buys a three-plow outfit to use only two plows for a few days until the tractor is worked in and he becomes accustomed to handling it, the salesman has rendered a great service, has saved the farmer money, and furthermore, has shown himself to be a real salesman.

Facts About the Industry

The farmers have been and are being lied to so much that some day not far distant they will pick out and appreciate the man who tells them the truth about tractors; this man will get their business and he will get it at his own price. The farmer owes himself a service if he wants to get the best there is from the tractor he buys. He must understand that everything the instruction book says is important.

The addition of lubricating oil just a few minutes too late may diminish the usefulness and shorten the life of a tractor by from 25 to 50 per cent. Every effort should be made to bring the farmer to realize that even if he buys a first-class tractor, its length of service largely depends upon his care, attention, and good judgment.

If we tell him everybody can run a tractor and it is all right to let everyone run it, we are doing him an injustice. The tractor should, where it is at all possible, be cared for and operated by one man, who should be held responsible for its condition. Every machine has its own individual peculiarities. Let us try driving some other cars of the same make and model as our own. We will find that no two of them can be handled alike. There will be variations in the throttle, the spark advance, the clutch, the steering wheel and the brakes; little differences that will worry us until we get accustomed to them.

Service as Citizen's Duty

Before I finish I want to go a little deeper into some of the things I have already mentioned in regard to service to the farmer in order to show that they are inseparably linked with the highest absolute service of the individual citizen as a citizen. We are today living in a critical period in our country's history, a critical period in the world's history. For over a generation life has been easy for us in this country. There really has been plenty for all, and everyone has taken all he could get. During these years we have lost a great deal of the real conception of citizenship; we have not known nor appreciated how well off we really were; we have been unappreciative of our privileges and remiss in the discharge of our duties.

If we wanted to design, manufacture and sell stuff that was junk, whose business was it but our own? We sold it cheaply enough, the customer got what he paid for, and he did not object very much; he bought better stuff the next time and threw the junk in the scrap pile. This may have been all right in the past, although I will not say that it was, but I say that today it is absolutely wrong. If we are designing, manufacturing and selling a product that we know is not as good as it could be, will not give as long service as it might if better designed and more carefully made, then we are neither giving the service to our customers nor to our country that is required of us. Why? Because we are using up both labor and material—the scarcest things in this country today—without obtaining the greatest results from that labor and material.

We have no right, more especially at this time, to waste the resources of our country. Our country demands more of us in service than carrying a rifle, buying Liberty Bonds, subscribing to the Red Cross and the many other things that we are called upon to do and that we are doing willingly and cheerfully. The full duty we owe to our country is not by any means purely a spectacular one; it is not something we do at odd times when we are through with what we are pleased to call our own private business, but is something that should pervade and dominate all of our activities. Therefore when we who are in the tractor business are not designing, building and selling to the American farmer the best tractor we can, we are not in the first place giving the farmer the best service within our power; in the second place we are not serving our country to the best of our ability; and further we are not as good citizens as we should be.

Following the same line of reasoning, the farmer who is not doing all he can to care for and operate properly the machine we build and sell him, who is overloading it, or leaving it out doors in all kinds of weather, is also wasting and destroying the resources of the nation. But it may be said that if the farmer can afford to buy tractors, or anything else, and destroy them through his carelessness, abuse and neglect, whose business is it but his own? In the past such a reasoning has stood because we have been the most prosperous, the most profligate and easiest going nation the world has ever seen; under the present conditions, and in the new future that is opening before us, such ideas will be classed under an ugly name, and they will be known as anarchy and treason.

History, the real history of the evolution of the human race and what we call civilization, if carefully studied, shows us that at all times the ideals of today become the commonplace facts and everyday practices of tomorrow. We, the American people, the greatest nation on the face of the earth, are nothing if not idealistic. Our very existence, the fact that we are a great nation, is because at every crisis that has arisen we have had men of high and far-reaching ideals who were ready to give everything, even their lives, for the attainment of these ideals.

We are, as a nation, stepping out from the mists, the superstitions, the misery and terrors of the ages of the past into a clearer light, a higher responsibility, a greater knowledge. Before us lies an untrodden path, a path that no nation has heretofore dared to tread, and our success will absolutely depend upon us individuals. If we are in harmony individually with the highest ideals of the nation, if in all our activities we practise unselfishness, then we as a nation can go far. But, on the other hand, if we are looking forward to greater and increased profits for ourselves, if, in other words, we are figuring on coining the blood, the misery, the wretchedness of our own and other peoples into gold, then we may as well join forces with the Kaiser, because in that case we differ from him only in degree and not in kind.

Author's Conclusion

In this paper I have consciously refrained from dealing with conventional things pertaining to the field service, and which we are expected to render our customer, the farmer. The keeping of adequate stocks of repair parts near customers, properly trained experts, how to train these experts, how to train salesmen and a host of other details, all these have been and are being thrashed over until they are threadbare. We know that these things are a vital part of any permanent business that deals with the farmers, and we also know that if these things are neglected we will soon have little or no business to attend to.

I want tractor engineers to think about some of the other things I have said. If they can blend a little more unselfishness into business there is no question about good service to the customer following as a natural consequence. I am not asking them to give anything away, but I am asking them to design and build the best tractors that can be built; first, because it is the greatest service they can render the farmer; and second, because it is the nearest duty they owe their country if they cannot carry a rifle.

We do not have to give first-class things away, neither do we have to sell them without a reasonable profit. A first-class article, an article that can demonstrate its quality by long and useful service, can always command a price commensurate to its value. We have only to look around us to see that the enterprises that are manufacturing the best grades of any kind of goods are the solid, permanent, dependable institutions. The man who makes these high-grade goods is usually the one with the first-class credit rating and bank account. Business failures are most prevalent among those who make the shoddy goods, the imitations. They spring up, flourish for a time and are gone simply because a low price and deceitful advertising never have and never will take the place of sterling quality, worth, and service.

Standardized Specifications for Lubricating Oils

By C. W. STRATFORD* (*Member of the Society*) *Illustrated with* CHARTS AND PHOTOGRAPHS

> **INTRODUCTION**
> By H. L. Horning
>
> For years engineers have been hoping for some measure of an oil's value as a lubricant in a particular service. The Society of Automotive Engineers is to be congratulated that the great war has given its members an opportunity to study the problem under the auspices of the Government, which has made it possible to develop this notable contribution to engineering. This paper is a result of the aid given by the Bureau of Standards, Bureau of Mines, Army, Navy and the Council of National Defense, and of Mr. Stratford's intimate knowledge of internal combustion phenomena and his experience in the art of refining oils.
>
> Two great engineering achievements meet here. Never before was it certain that the performance of an oil could be predicted. Under the systems proposed it is as sure as is the measuring of a piston. I commend the careful study of this article to all engineers, refiners and industries using oils. It is to be earnestly hoped that law-making bodies will use it as a foundation on which to build a rational system of testing lubricating oils and thus lift this art from the realm of alchemy to the sphere of modern science.

IN all industries the tendency toward standardization has never been stronger than at present. Under stress of war, international standardization committees are now the order of the day. The work done by these committees has been fruitful in securing the highest degree of quality, suitability and manufacturing efficiency. The oil industry appears to be one of the few remaining in which no effective standardization has been brought about. It is generally recognized that there is real need for some dependable method or methods of distinguishing between good and poor lubricating oils.

The advent of internal-combustion engines has introduced a new and important element in the lubrication of machinery, namely, much higher operating temperatures. Oils in these engines not only are exposed to high temperatures, but also are brought into intimate contact with carbureted air and products of partial or complete combustion, which contaminate them.

When the science of internal combustion-engine design was in its early stages little attention could be spared for the proper study of explosion-engine lubricants. As this type of engine approached perfection a difference in lubricating oils was soon perceived in service. Engine manufacturers soon found that certain oils gave good results while others were unsatisfactory. As their chief task, however, has been to produce engines, and not oils, their attention has been concentrated exclusively within their own field. In rare instances some engine manufacturers have made exhaustive experiments with lubricating oils, assuming that such oils bought in lithographed tins would always be of uniform quality if called by the same trade name. This assumption, erroneous on their part, has resulted in the complete nullification of much good that might have been derived from such engine tests. Unfortunately, intelligent tests cannot be made on lubricating oils in heat engines unless they are planned and carried out by operators who thoroughly understand all the features of internal combustion engine operation, as well as the fundamentals of hydrocarbon chemistry and the important secrets of the oil-refining industry. Lubricating efficiency and oil quality are distinctly a chemical matter, hence any specification seeking to limit quality and to definitely fix suitability and uniformity must repose upon a strictly chemical or physico-chemical basis.

There are so many variables in the operation of internal-combustion engines that unless all tests are run under carefully studied and uniformly limited conditions no comparison can be made with the results obtained from the lubricants in practical use. Because of the difficulty and of the great expense attached to the execution of such tests it is obvious that they should be supplanted by some laboratory methods which would make possible the determination of the same qualities and defects that are brought into unmistakable evidence in properly run engine tests or in actual service.

One of the first attempts to establish such laboratory tests was made by trying to apply the heat and the emulsion tests in the determination of the practical service value of lubricating oils. Oils that permanently emulsify with distilled water were found to rapidly decompose when used in an engine. Hydrocarbon oils showing a poor emulsion test also always suffer an undesirable decomposition when exposed to heat. Increased familiarity with these two tests soon proved to oil refiners that the best public demand was for engine oils that showed up most favorably under such tests. But the indications of these two tests were proved to be too limited to serve as a basis for judging all oils. When no "sulpho" compounds or highly unstable hydrocarbon compounds were present the results obtained were negative. Consequently, other tests had to be evolved that would indisputably and definitely prescribe the stability (meaning resistance to chemical change) and the suitability (correct volatility for the operating conditions) of all oils for use in internal-combustion engines.

In the light of the most recent study and exhaustive experimentation, the oxidation test appears to be the only dependable and satisfactory method by which the stability of oils can be predicted when they are used in service. The main facts shown by this test are the evaporation loss and the rate at which solid hydrocarbons are formed by polymerization or precipitation when oils are exposed to working conditions of an engine.

The distillation of finished oils under a high vacuum offers an unfailing means of determining their constituents; that is, of what groups of hydrocarbons, highly volatile or less volatile, the finished oils may consist. This test is a useful supplement to the oxidation test.

In the oxidation test oils are exposed to a uniform high temperature and the surface of the oil under test is swept by a continuous current of air, thus duplicating actual conditions to be met with in an engine.

Fractionation under conditions of high vacuum is an excellent method of making an approximate analysis of finished lubricating oils, since it permits of separating

*President Dixie Chemical Corp., Petersburg, Va.

the volatile from the less volatile portions in graduated fractions. When oils show high evaporation loss the oxidation test alone cannot explain the reason for this loss. Evaporation may occur because of natural volatility or because of the occurrence of "cracking," that is, decomposition of the oil into light portions and heavy liquid or solid hydrocarbon residuals.

Customary Routine Tests

Before giving an extended description of the apparatus and the method of making the test it is, perhaps, well to discuss certain routine physical tests that have become traditional to the oil industry and to the oil consumer.

The problem of differentiation between groups of hydrocarbons sold under trade names is a different matter when viewed from the angle of the oil refiner, as compared to that of the final consumer. The oil refiner must have some practical tests that suffice for his purposes, but that during the processing of his distillates may enable him to produce oils having uniform properties.

A perfect knowledge of his crude oil, as well as a familiarity with all of the distillates from that crude oil, automatically build up for the refiner a series of standards which, though significant to him, are meaningless to the consumer. In most instances these standards are of little value to other oil refiners who are handling crudes of different characteristics. The meaning of these customary routine tests—gravity, flash, fire, viscosity, cold test and color—may be taken as examples. By these tests oil refiners accustomed to handling some specific crude or mixtures of crudes soon become so familiar with their distillates as to be able to condemn or approve any distillate in any stage of refining.

Gravity Test.—The first separation of crude oil into its distillates is usually controlled by their gravity. This test also indicates to the oil refiner the geographical source of the crude oil. Formerly, all oil refiners judged the quality of the light volatile products, such as fuels for engines, by gravity alone. Present-day developments, however, have shown that this is not a proper indication of volatile fuel characteristics. Gravity, as applied to any petroleum product, is of no practical significance to the consumer.

The flash test is used by oil refiners as a measure of volatility. The very lightest products, such as gasoline, are not controlled by a flash determination. The flash point of all other distillates and residues is generally used as an indication for necessary separation of distillates into their required fractions. The flash test made on products not contaminated is an indication of the same property as shown by the fire test. When the products are contaminated the fire test shows more nearly the real constituents of the oil examined.

Neither flash nor fire tests are of major importance to the consumer because the real volatility of oils, as determined by distillation under high vacuum, gives him a true measure of oil economy in service.

Cold Test.—The cold test is usually applied only to lubricating oil fractions, and is employed by the refiner to control the finishing of his products. It is of importance to the consumer in determining the suitability of oils for use under certain climatic conditions.

Viscosity Test.—The viscosity of his products is of concern to the oil refiner only in to far as it may be required to meet the demands of the consumer. Through practical experience the consumer has learned what the correct viscosities of lubricants should be for different types of machinery.

Color Test.—As the petroleum industry developed, certain products were gradually accepted as standard because of their most obvious characteristic, color. It has long been customary to include the color value of an oil as a necessary marketing requisite, along with its other properties. The refiner takes the color of oils into consideration as being a valuable indication of their uniformity, it being also a check on correct processing. Although in the past color was considered as an indication of purity, it has been demonstrated beyond any doubt that it alone means nothing in service to the ultimate user.

The unusually rapid development of aviation engines, and their importance for war purposes, have been the direct causes for further investigation and the carrying out of intensive study of the relative qualities of all available lubricating oils in the American market, special and otherwise, intended for use in automobile, truck and aircraft engines. In continuing this study, naturally, due consideration was given to routine oil testing as now made by oil refiners. Of these tests, gravity, flash, fire and color were soon eliminated as being non-essential, because they gave no decisive indication of the decomposition of an oil when exposed to heat. The viscosity, cold test, volatility, susceptibility to oxidation, and emulsifying properties were substituted as being the only tests actually required. These five tests have been found to prescribe completely and accurately the stability and suitability of lubricants for the above-mentioned engines.

Recommended Lubricating Oil Specifications

The following specifications, which are recommended by the author for lubricating oils to be used in internal-combustion engines, are based on the five tests determined to be essential. In order to put them into force it would be absolutely necessary to standardize the apparatus used in the determination of all the properties indicated. This also applies to the standardization of petroleum ether. Given below are a description of this apparatus and the specifications of the petroleum ether, both of which are recommended for standardization.

The nomenclature used for designating the specifications is as follows: Aircraft engine oils, A. E. O.; automobile and truck engine oils, A. T. O.; and Knight sleeve-valve engine oils, K. S. V. O. The air-cooled motorcycle engine oils are not given a separate designation, since the oils specified for other duty can be used.

AIRCRAFT ENGINES

A. E. O. No. 1 (High Altitude or Low Altitude Winter)

1. Viscosity at 212 deg. fahr., seconds . 58 to 70; desired 65
2. Cold test..................... Maximum 40 deg. fahr.
3. Boiling-point range,
   Maximum 4 per cent under 300 deg. cent.
4. Oxidation........ Insolubles, maximum 0.20 per cent
   Evaporated loss, maximum 40 per cent
5. Emulsion .... Maximum trace

A. E. O. No. 2 (Low Altitude Summer)

1. Viscosity at 212 deg. fahr., seconds . 80 to 90; desired 85
2. Cold test..................... Maximum 45 deg. fahr.
3. Boiling-point range,
   Maximum 4 per cent under 300 deg. cent.
4. Oxidation..... Insolubles, maximum 0.20 per cent
   Evaporation loss, maximum 40 per cent
5. Emulsion .... Maximum trace.

AUTOMOBILE AND TRUCK ENGINES

A. T. O. No. 1 (Summer)

1. Viscosity at 212 deg. fahr., seconds . 52 to 60; desired 55
2. Cold test..................... maximum 35 deg. fahr.
3. Boiling-point range,
   Maximum 30 per cent under 300 deg. cent.

PROPERTIES OF REPRESENTATIVE AMERICAN LUBRICATING OILS FOR USE IN INTERNAL COMBUSTION ENGINES

Kind of Oil	Physical Properties Fresh Sample									Lovibond Color		Vacuum Distillation	Oxidation Oven		
	Baumé Grav.	Flash, Deg. F.		Deg. F Burn	Deg. F Chill	Viscosity, Seconds			Fresh	After Heat Test	% Dist. Under 300° C.	% Evap. Loss	% Insol.	% Varnish
		Open Cup	Closed Cup			100°F	150°F	212°F						
Aerial Oil	29.1	425-	410	490	50	593	176	71	550-2	670-2	13	18.98	0.0240	0.1875
Amalie Special	31.0	420	425	490	40	209	80	43	430-6	500-2	4	31.71	0.0220	0.3300
Atlas Aerul Heavy	27.6	460	460	540	47	868	228	85	400-½	600-½	328° I.B.P.	17.84	0.0120	0.1081
Cadillac Detroit Lt.	28.2	405	....	470	11	190	69	...	300-6	......	44	......	......	......
Duplex No. 350	30.7	425	435	495	27	194	77	46	240-6	250-2	1	21.49	0.0596	0.1760
Havoline														
Light	25.9	370	380	430	33	173	66	42	540-6	300-½	22	62.93	0.5500	0.6300
Medium	25.0	385	395	450	34	237	80	46	570-2	500-½	6	57.74	0.8600	0.3400
Heavy	25.6	395	410	455	46	361	111	54	480-2	300-½	18	40.49	0.1500	0.2800
Mobiloil														
Zeta Light	28.0	375	380	430	31	141	62	42	360-6	200-½	28	51.75	0.3010	0.3816
Zeta Medium	24.2	400	410	470	43	255	84	47	460-2	300-½	29	35.06	0.2599	0.2776
Zeta Heavy	25.6	420	425	480	42	476	137	62	500-½	650-½	301° I.B.P.	27.64	0.0404	0.2339
"E" Light	26.1	370	380	420	0 @ 0	167	66	44	430-6	400-2	21	76.44	0.1962	0.1580
"A" Medium	21.8	360	360	420-	24	330	97	49	660-2	320-½	21	57.66	0.6381	0.1612
"B" Heavy	26.3	500	470	580	41	1640	397	122	800-½	950-½	3	25.26	0.1766	0.1500
Arctic Lt. Med	23.3	370	380	425	6	221	74	45	280-6	400-2	28	71.52	0.3993	0.4759
Arctic Medium	21.1	370	385	430	8	300	87	46	550-6	210-½	19	49.06	0.4160	0.5065
"BB" Med. Hvy	25.8	460	....	540	46	926	243	86	670-½	800-½	344° I.B.P.	18.67	0.0290	0.0560
Monogram														
Light	27.6	360	360	410	20	140	60	41	200-6	260-2	14	67.12	0.4600	0.5700
Medium	26.0	375	370	430	23	289	95	50	600-6	250-½	16	46.19	0.1600	0.2600
Heavy	28.9	430	445	505	34	340	108	55	600-6	580-2	306° I.B.P.	25.75	0.0700	0.3600
Ex. Hvy	24.7	465	425	555	58	1583	356	110	330-½	470-½	3	12.10	0.0440	0.2056
Oilzum														
Heavy	29.1	430	440	500	30	261	91	50	460-6	420-2	310° I.B.P.	15.86	0.1167	0.1357
Crystal G. E. Oil	17.0	505	490	590	2	1080	244	83	100-6	140-2	....	17.54	.....	.....
Perfection														
"A" Light	29.1	400	410	470	26	181	71	45	420-6	430-2	314° I.B.P.	49.36	0.1378	0.2387
"B" Medium	24.9	390	400	450	32	243	81	47	440-2	480-½	2	52.33	0.3704	0.2629
"C" Heavy	29.3	420	430	495	40	316	103	54	480-2	300-½	2	27.53	0.0088	0.2292
Polarine, New Jersey	24.6	395	....	470	6	221	77	42	150-6	850-2	57	48.73	0.6200	0.4300
Quaker State Medium	28.8	440	450	520	21	301	102	48	600-6	700-2	29	22.42	0.0649	0.1700
Service Auto Oil	24.3	390-	....	460	33	195	72	44	500-2	440-½	7	58.91	0.9600	0.4100
Socony														
Zero	24.3	395	410	470	Sl. @ 0	219	77	46	140-6	250-2	3	42.85	0.1531	0.2167
Polarine Hvy	25.4	385	380	450	35	300	103	51	380-2	420-½	7	38.61	0.1353	0.2128
Supreme														
Light	22.3	325	315	360	Sl. @ 0	137	57	39	420-6	250-2	73	60.21	0.7689	0.3531
Medium	19.8	330	330-	380	Sl. @ 0	217	73	43	530-6	220-½	49	56.57	0.7041	0.3243
Heavy	19.4	330	330	370	0 @ 0	242	73	44	560-6	200-½	42	53.37	0.4609	0.3063
Texaco														
Light	21.3	335	340-	380	Sl. @ 0	205	69	42	190-6	260-2	44	56.13	0.1395	0.2371
Medium	20.9	350	350	400	Sl. @ 0	301	85	46	190-6	350-2	31	51.40	0.1009	0.2163
Heavy	19.3	355	360	420	10	495	119	51	330-6	450-2	19	42.87	0.0874	0.2097
Ursa	19.7	390	365	455	Sl. @ 0	735	152	58	240-6	360-2	....	37.63	0.2757	0.3562
Valvoline Medium	30.7	385	390	440	30	257	93	51	480-2	300-½	29	38.85	0.0250	0.1714
Veedol														
Aero No. 1	26.2	455	450	535	39	795	212	78	580-2	300-½	3	34.96	0.3956	0.1504
Aero No. 2	27.1	450	445	530	38	814	222	80	580-2	310-½	3	36.58	0.1614	0.1900
Aero No. 3	26.3	435	435	520	38	517	149	63	470-2	260-½	318° I.B.P.	37.98	0.0358	0.1738
Aero No. 4	27.6	440	430	515.	34	513	151	64	500-2	250-½	3	38.11	0.0416	0.2130
Aero No. 5	24.7	440	450	520	28	413	135	55	470-6	580-2	336° I.B.P.	38.33	0.0741	0.4151
Aero No. 6	24.7	460	460	540	27	474	134	58	480-6	550-2	318° I.B.P.	18.91	0.0732	0.2284
Zero Light	26.1	390	....	460	14	199	75	44	380-6	370-2	57	39.56	0.4548	0.2717
Medium	26.3	405	....	475	30	250	88	48	530-6	520-2	23	49.54	0.0201	0.2348
Heavy	26.2	410	....	480	33	329	107	52	700-6	650-2	28	30.08	0.0659	0.1719
Extra Heavy	26.1	465	....	550	44	...	355	111	310-½	450-½	3	9.02	0.0464	0.1155
Waverly	31.0	400-	405	460	24	160	69	40	300-6	570-2	37	44.76	0.1400	0.2900
White Star Motor Oil	25.8	360	370	415	18	170	66	43	500-6	800-2	17	59.65	0.4800	0.7500
Wolf's Head														
Light	31.2	390	....	445	34	142	62	40	130-6	210-2	1	58.70	0.1750	0.4800
Medium	28.8	410	....	470	26	223	82	46	410-6	350-¼	310° I.B.P.	45.05	0.3800	0.2700
Heavy	28.6	415	....	475	32	334	108	52	480-6	750-2	304° I.B.P.	35.50	0.2100	0.2000
No. 8	27.6	465	460	550	46	1196	300	100	680-6	380-½	3	38.83	0.0470	0.2960

4. **Oxidation**.....Insolubles, maximum 0.30 per cent
Evaporation loss, maximum 40 per cent

5. **Emulsion** ....Maximum trace

A. T. O. No. 2 (*Winter*)

1. **Viscosity** at 212 deg. fahr. seconds. 45 to 50; desired 48
2. **Cold test**...................Maximum 30 deg. fahr.
3. **Boiling-point range**,
Maximum 30 per cent under 300 deg. cent.
4. **Oxidation**.....Insolubles, maximum 0.30 per cent
Evaporation loss, maximum 50 per cent
5. **Emulsion**..........................Maximum trace

KNIGHT SLEEVE-VALVE OIL

K. S. V. O. (*Summer*)

1. Viscosity at 212 deg. fahr., sec. 100 to 120; desired 115
2. Cold test...................Maximum 52 deg. fahr.
3. Boiling-point range,
Maximum 3 per cent under 300 deg. cent.
4. Oxidation......Insolubles, maximum 0.20 per cent
Evaporation loss, maximum 30 per cent
5. Emulsion..........................Maximum trace

Winter, use A. E. O. No. 2

AIR-COOLED MOTORCYCLE ENGINES

Winter—One and two-cylinder types, use A. E. O. No. 2
Four-cylinder types, use A. T. O. No. 1
Summer—One and two-cylinder types, use K. S. V. O.
Four-cylinder types, use A. E. O. No. 2

I. VISCOSITY

It will be necessary to determine only the viscosity at

212 deg. fahr. For the purposes of a more thorough investigation the rate of fall of viscosity between low and high temperatures, three points may be found: 100, 150 and 212 deg. fahr.

Care should be exercised in maintaining the temperature of the oil being run at 212 deg. fahr.

The instrument used will be a standard Saybolt universal viscosimeter.

Limit of error plus or minus one second.

II. Cold Test

The cold-test box (18 by 18 by 14 in. high) is filled about three-quarters full with ice and salt mixture (about 10 to 1 by volume). Copper cylinders 9 in. high, and having an inside diameter of 2 in., are inserted in this mixture so that the tops of the cylinders are about level with the surface of the ice and salt mixture. Regular 4-oz. oil sample bottles and approximately 5-in. immersion, cold-test thermometers, having a range of from 20 to 140 deg. fahr., complete the equipment. The procedure of test is as follows:

A sample bottle is filled about one-third full of oil, and a cork, carrying the thermometer, inserted in the neck of the bottle so that the bulb of the thermometer is immersed in the oil. The sample is then placed in one of the copper cylinders. The bottle should not be allowed to come in contact with the bottom of the tube, a thin section of cork being interposed between the two. The temperature of the oil, as shown by the thermometer, is carefully observed, and at each drop of 2½ deg. fahr. the sample is removed and examined. The temperature at which the oil just refuses to flow when the bottle is held in a horizontal position is taken as the cold test.

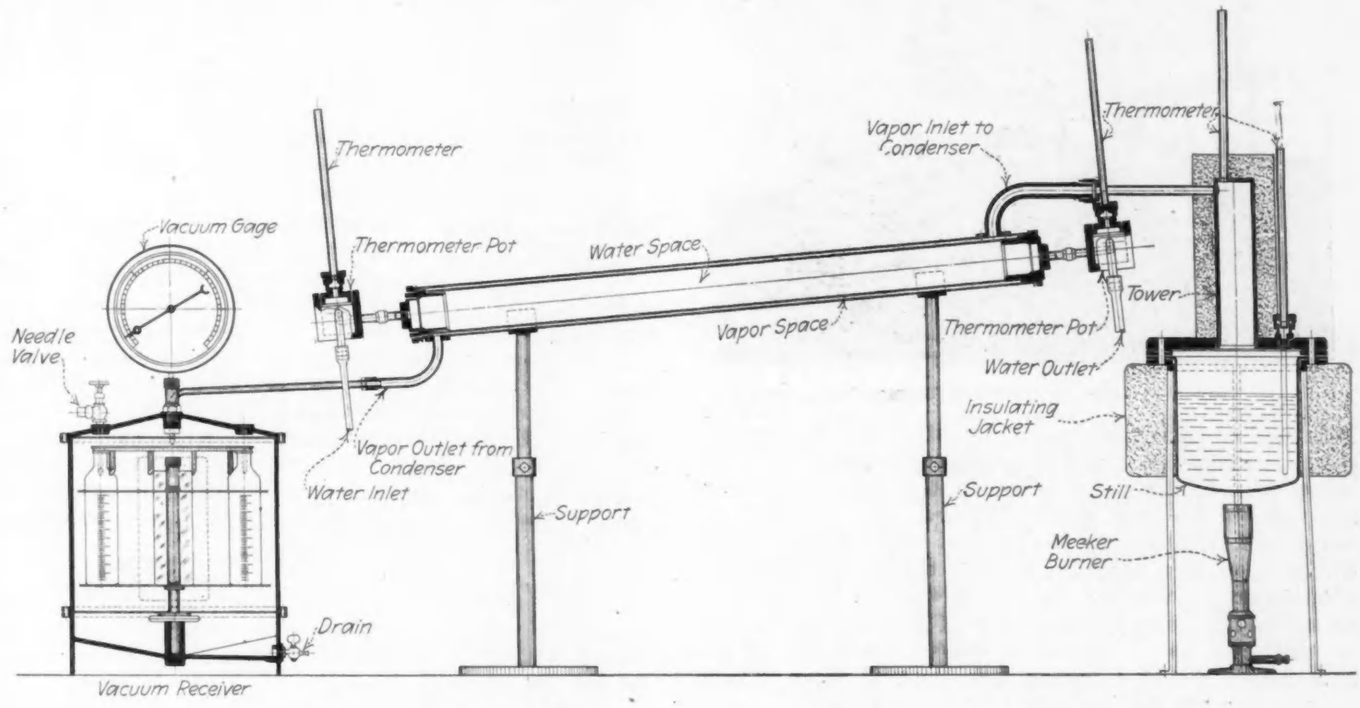
The above method is for oils having a cold test under 40 deg. fahr. Those having cold tests above this point are tested as follows:

The point at which the oil just refuses to flow is obtained in exactly the same manner as described above, and the oil is then chilled 20 deg. fahr. below this point. The sample is then removed and placed in water which is kept just 5 deg. warmer than the oil, as shown by the thermometer in the bottle. The sample is tested at each 2½ deg. fahr. increase in temperature, and the temperature at which the oil will flow evenly across the bottle when it is held in a horizontal position is called the cold test.

The limit of error is plus or minus 2 deg. fahr.

Annapolis Pour Test.—The procedure is exactly the same as that given above for oils under 40 deg. fahr. cold test, except that 5 deg. fahr. is added to the point observed as cold test and is reported as pour test.

The above method is used for all oils except black oils. The cold test for black oils is taken at the Annapolis Experimental Station as follows:



Cross Section of Vacuum Distillation Apparatus Showing Receiver, Still and Other Parts

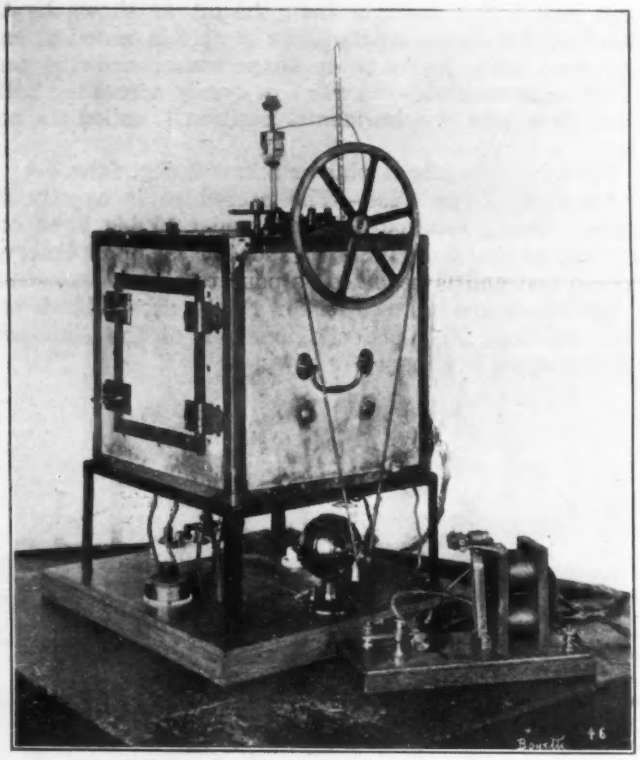
The oil is chilled by exactly the same procedure as above; when the oil just refuses to flow the sample is removed, the bottle held horizontally, and the oil stirred with the thermometer. The temperature when the oil flows freely is recorded as the pour test.

A. S. T. M. Pour Test.—The method specified by the A. S. T. M. is exactly the same as that used at the Annapolis Station, except that the sample shall be removed and tested for every 5 deg. drop in temperature, instead of 2½ deg. fahr., as used at Annapolis. The difference between the A. S. T. M. and Annapolis methods is about 2 deg., and generally the Annapolis method will give the higher test.

III. Boiling-Point Range (Vacuum Distillation)

The apparatus for making this test consists of a special steel still and vapor tower, a special water-cooled condenser and chamber for the distillate receivers. The position of these receivers can be adjusted from the outside without alteration of the pressure in the distillation system. The distillation system is connected with a pump capable of maintaining a vacuum of 2½ mm. absolute and having a capacity of 6 cu. ft. per minute.

The still is charged with 2000 cc. of the oil under examination. The standard vacuum, 40 to 50 mm. absolute, is established throughout the closed system, and



Oxidation Oven of Modified Waters-Type

heat applied to the bottom of the still. For the purpose of the specification it will be necessary to carry the distillation only to the point at which the still temperature has reached 300 deg. cent. (572 deg. fahr.). The percentage of distillate up to 300 deg. cent. has been arbitrarily taken as a basis for judging the relative volatility of different lubricating oils. However, for the ultimate analysis of finished lubricating oils, the distillation may be continued up to the point where nine-tenths of the total charge will have passed over, the rest being allowed to remain in the still, and estimated as residual.

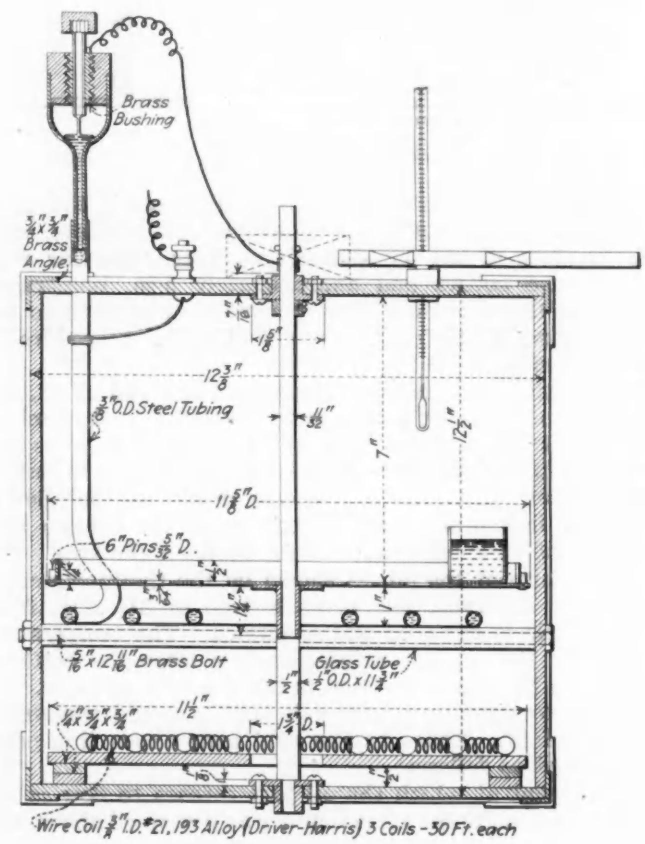
The fractionation of finished lubricating oils under high vacuum is a satisfactory way of determining boiling-point limits with the least decomposition. The quantity of low-boiling-point fraction varies widely in lubricating oils intended for use in different types of internal-combustion engines. All engines that operate under approximately full load and at high temperatures (aviation engines) should contain a minimum quantity of low-boiling-point fractions, say 4 per cent distilling under 300 deg. cent. The results obtained by actual tests in aircraft engines clearly demonstrate this point. On the other hand, passing from such conditions of high operating temperatures to those of widely varying and comparatively low operating temperatures (passenger cars and trucks), it is necessary to increase materially the quantity of low-boiling-point fractions to prevent serious carbonization. There is a limit, however, to the addition of low-boiling-point fractions, for the reason that too large a quantity will greatly increase the specific consumption of the lubricant in service, hence some mean value must be fixed upon, a permissible balance being struck between carbonization and high consumption. An analysis of the most successful automobile oils now sold shows that not over 30 per cent of the oil should distill below 300 deg. cent. in the vacuum distillation apparatus described. This volatility is a guarantee of a reasonably low specific consumption, good lubrication and minimum carbonization within the explosion chambers.

Oxidation Test

The apparatus for making the oxidation test consists of a cubical box constructed of heat-insulating material. Through the vertical axis of this box passes a shaft, at the center of which is attached a disk of about 11 in. diameter. This disk and shaft are rotated at a speed of 25 r.p.m. The containers for oil samples are steel cups cut from the solid, 50 mm. inside diameter, plus or minus 0.04 mm.; and 50 mm. high, plus or minus 0.4 mm. The cup wall is 1 mm. thick. The oven is electrically heated by resistance coils, and the temperature is maintained constant and regulated by a thermostat. Air circulation is provided through holes in the bottom of the sides of the oven and through the top. The determinations made in this oven are:

1. Evaporation loss.
2. Petroleum ether insolubles.
3. "Varnish."

Fifty grams of the oil are weighed into the cups, and these are placed at equal distances at the outer edge of the rotary disk. The temperature is brought to 225 deg. cent., and the test is continued at this uniform temperature for twelve hours, in two periods of six hours. The samples are then removed and allowed to cool, weighed, and the loss in weight (per cent) recorded as evaporation loss. The contents of the cups are then washed through a Gooch crucible with standardized petroleum ether (see below) until the filtrate is colorless. From the crucibles on which remain the insoluble residue the petroleum ether is allowed to evaporate, after which they are introduced into a Freas oven and thoroughly dried at a temperature

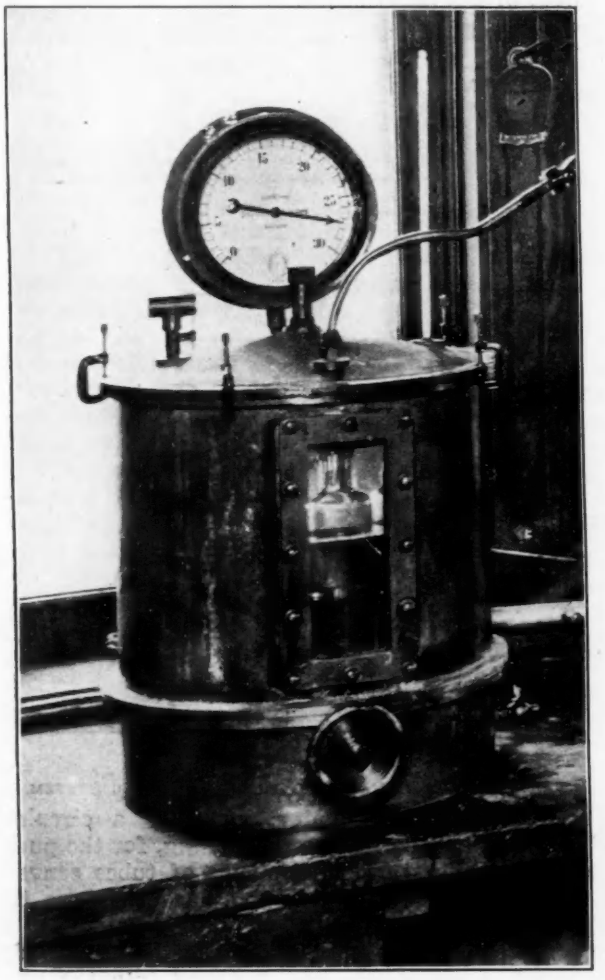


Cross Section of Oxidation Oven

of 105 deg. cent. The weight of the residue is then determined and the percentage recorded as petroleum ether insolubles.

When the metal cups have been thoroughly washed with petroleum ether there still remains a varnishlike residue, which clings to the upper walls. The weight of this substance is determined and recorded as "varnish."

The real significance of "varnish" values has not been clearly established up to the present. Poorly refined oils, however, also those from some mid-continent and from California crudes, usually show high "varnish" values.



RECEIVER FOR DISTILLATION APPARATUS

The maximum variation of checked results on evaporation loss and petroleum ether insolubles should not exceed 2 per cent.

It has been found that the evaporation loss of an oil does not always coincide with its boiling-point range; therefore, it seems permissible to conclude that the evaporation loss is a measure of the decomposition of an oil, as well as of its volatility. In judging oils it is important to observe carefully the relation between the boiling-point range and the evaporation loss. For example, an oil may have a high boiling-point range, and yet, owing to its instability, may readily decompose when exposed to heat, and thus show a high evaporation loss.

The petroleum ether insolubles indicate, on the one hand, the solid carbonaceous matter formed in an oil, which splits up, when exposed to heat, into light volatile ends and solid products. On the other hand, these insolubles may indicate the precipitation of colloidal carbon or other products in improperly refined oils. Values of petroleum ether insolubles may be entirely independent of those of boiling-point range or evaporation loss.

Standardized Petroleum Ether

For the determinations of petroleum ether insolubles it is imperative that a standardized petroleum ether be employed, such as the following:

Petroleum ether should be made from steam-stilled Prime City naphtha from Pennsylvania crude, which has the following properties:

Gravity, deg. Baumé, 72 to 76.

Initial boiling point, deg. fahr., 110 to 122.

Final boiling point, deg. fahr., not over 270.

Petroleum ether should conform to the following specifications:

Gravity, deg. Baumé, 77 to 80 (the matter of gravity is unimportant).

Initial boiling point, deg. fahr., 110 to 120.

Final boiling point, deg. fahr., 220 to 245.

Unsaturated content not over 4 per cent by absorption in sulphuric acid (Bureau of Mines method).

The Saybolt distillation method applies to both of the above boiling point ranges.

V. EMULSION TESTS

In making emulsion tests the simple apparatus described below gives excellent check results.

The apparatus consists of a Coles milk shaker slightly altered to receive two 4-oz. oil sample bottles. The shaker is operated at a speed of 600 r.p.m., and has a 2-in. stroke.

About $1\frac{1}{2}$ in. of oil and an equal quantity of distilled water is poured into the bottles, which are then corked and placed in the machine. These are shaken for half an hour, after which they are removed and allowed to stand at room temperature for 24 hours. The amount of unseparated oil is then determined and recorded as emulsion.

The above method applies only to oils having a viscosity not exceeding 50 sec. at 212 deg. fahr. When the viscosity exceeds this figure the oil should be blended with 50 per cent of standardized petroleum ether before shaking.

For the purpose of the specification the emulsion value of an oil can be considered as a quantitative test for "sulpho" compounds.

AUTHOR'S CONCLUSION

These investigations were suggested by H. L. Horning, chairman of the Automotive Products Section, War Industries Board, Council of National Defense, who requested the author to make a thorough study of hydrocarbon lubricants for aircraft engines in the search for the best oil. The specifications as drawn above represent the results of these studies, which were begun in June, 1917, and terminated early last December.

In securing the data on which these specifications are based valuable assistance was received from a number of sources. The Tidewater Oil Company, Bayonne, N. J., permitted the author the use of its extensive laboratories for a number of months with the full collaboration of S. E. Campbell, chief chemist.

Credit should also be given Dr. C. E. Waters of the Bureau of Standards for information furnished regarding his oxidation oven and tests. Dr. E. W. Dean of the Bureau of Mines made valuable suggestions relative to the distillation of hydrocarbons under high vacuum.

Vol. II February, 1918 No. 2

Principles of Tractor Engine Cooling

By ARTHUR B. MODINE* (*Member of the Society*)

MINNEAPOLIS SECTION PAPER *Illustrated with* CHARTS

THERE are many factors, other than radiator size, involved in tractor engine cooling. The principal variables pertain to radiator type, radiator core thickness or degree of cooling capacity, rate of water circulation, size, type and speed of fans, and the economy characteristics of the engine to be cooled. I do not consider it practical to evolve a formula covering all the branches of gas engine operation, but believing the time opportune for a certain degree of standardization of the variables referred to, I shall go into some of the essentials of cooling involved in our particular branch of the automotive industry, and, in conclusion, will give a formula for radiator sizes and recommendations for water circulation, air velocity and fan details.

Gas engine cooling involves a diversity of elements in engine design, all affecting the economy of the engine, and ultimately, for our purpose, that proportion of heat input showing up as jacket loss.

Equation I is our introductory and basic formula, in which

Heat to radiator = Heat input — Heat equivalent of horsepower developed — Exhaust loss — Engine radiation and convection losses. (I)

All the factors of this equation for any given engine are computable, but for general use certain assumptions are required together with the introduction of a variable factor.

Equation II is based on observed average performances.

$$\text{Heat to radiator} = 0.40 \text{ heat input} \times F. \qquad \text{(II)}$$

where F is a variable with a value of 1.0 in the case of L-head engines ranging from 25 to 50 hp. and 0.8 in the case of valve-in-head engines of the same power range. Individual peculiarities of jacket design, piston speed, compression, proportion of engine radiation and convection loss and valve design, would all, of course, further affect the value of the variable, but I believe that the formula, as suggested, will be found sufficiently accurate for our purpose.

Taking average tractor engine economy as 0.75 lb. of gasoline per hp. per hr., and a heat value per pound of gasoline as 20,000 B.t.u., we find that Equation II, applied to the L-head type engine, becomes

Heat to radiator per min. per hp. =

$$\frac{0.40 \times 0.75 \times 20{,}000 \times 1}{60} = 100 \text{ B.t.u.} \qquad \text{(III)}$$

So, if we are to cool a 30-hp. L-head engine under full load, it is necessary to provide cooling capacity equivalent to $30 \times 100 = 3000$ B.t.u. per min.

It is interesting to note how this quantity of heat would manifest itself were no means available to dissipate it other than the evaporation of water. The 3000 B.t.u. per min. would evaporate about 3 lb. of water per min., 180 lb. per hr., or about 21½ gal. per hr. Double this to 43 gal. per hr. for, say, a 60-hp. load, and we get an idea of the difficulties that confronted the pioneers in the tractor industry in getting a sufficient supply of tank capacity. Aside from other considerations, it is manifestly impractical to carry around a great bulk of water such as would be required; to meet these conditions, it has been found necessary to transfer this waste heat to the surrounding atmosphere through the medium of the conventional radiator and cooling system shown in Fig. 1.

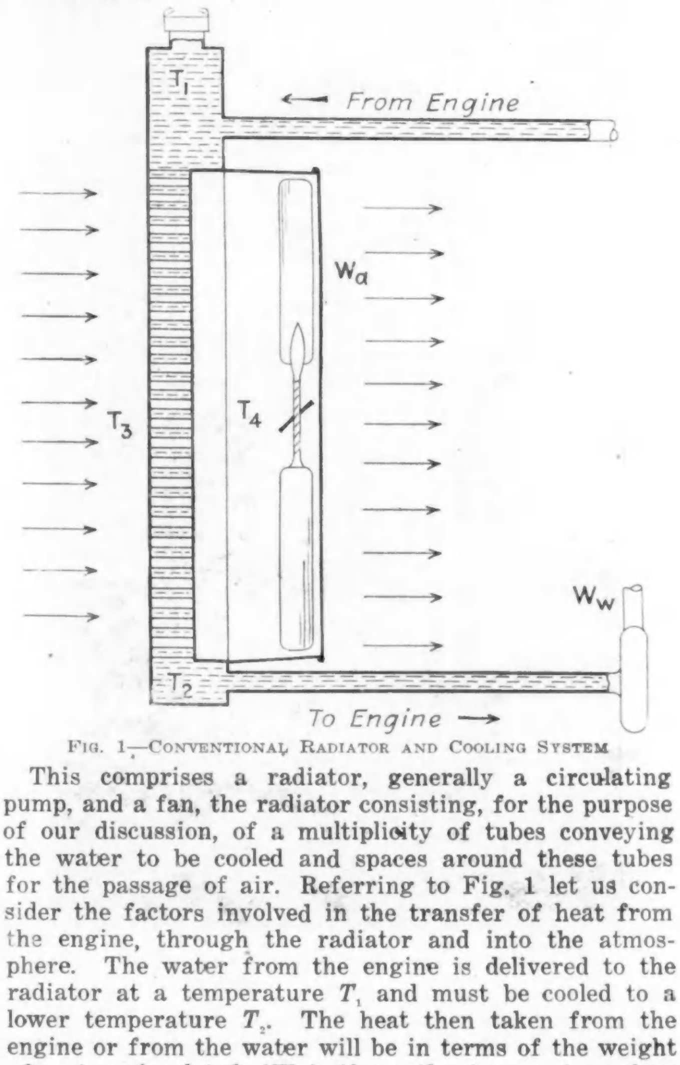


FIG. 1—CONVENTIONAL RADIATOR AND COOLING SYSTEM

This comprises a radiator, generally a circulating pump, and a fan, the radiator consisting, for the purpose of our discussion, of a multiplicity of tubes conveying the water to be cooled and spaces around these tubes for the passage of air. Referring to Fig. 1 let us consider the factors involved in the transfer of heat from the engine, through the radiator and into the atmosphere. The water from the engine is delivered to the radiator at a temperature T_1 and must be cooled to a lower temperature T_2. The heat then taken from the engine or from the water will be in terms of the weight of water circulated (W_w) times the temperature drop ($T_1 - T_2$) effected upon it by its passage through the radiator and may be expressed as $W_w(T_1 - T_2)$. It is evident the heat removed from the water must (under normal operating conditions) equal the heat imparted to the air, and will be measured in terms of the weight of air circulated (W_a) times the temperature rise ($T_4 - T_3$) effected upon it by its passage through the radiator, or $W_a(T_4 - T_3)$.

From this balance we get Equation IV.

$$W_w(T_1 - T_2) = W_a(T_4 - T_3) \qquad \text{(IV)}$$

which, expressed in foot-pound-second units, becomes in equation V:

$$\begin{aligned} W_w(T_1 - T_2) &= V_a \times 0.071 \times 0.2375(T_4 - T_3) \\ &= 0.01685 V_a(T_4 - T_3) \qquad \text{(V)} \end{aligned}$$

*President of the Modine Mfg. Company.

in which W_w is weight of water in lb.; V_a is volume of air in cu. ft.; 0.071 is the weight of 1 cu. ft. of air at 100 deg. fahr.; 0.2375 is the specific heat value of air.

Equating this last relation with Equation III we get

Heat to radiator per min. per hp. = 100 B.t.u.

$$= W_w(T_1 - T_2) = 0.01685 V_a(T_4 - T_3). \quad \text{(VI)}$$

from which we derive

$$W_w \text{ (or lb. water) per min. per hp.} = \frac{100}{T_1 - T_2} \quad \text{(VII)}$$

$$V_a \text{ (or cu. ft. air) per min. per hp.} = \frac{100}{0.01685(T_4 - T_3)} = \frac{6000}{T_4 - T_3} \quad \text{(VIII)}$$

and from Equation VIII, inasmuch as the volume of air is a function of its velocity and area, we get

$$\left.\begin{array}{l}\text{Square feet frontal area}\\ \text{of radiator per hp.}\end{array}\right\} = \frac{6000}{v\ (T_4 - T_3)} \quad \text{(IX)}$$

in which v is the air velocity in feet per minute. These values are all dependent upon the value of the factor F in Equation II. This factor has been omitted to avoid the use of too many symbols, but in view of its value of 1 for L-head types, the formulas will apply directly as they are to this type while for the valve-in-head classification they are to be multiplied by the factor F with value 0.8, as designated.

From an analysis of Equation IX we see that our problem of cooling or of radiator size has resolved itself into two factors: the temperature rise effected upon the air, and the velocity of the air. I have made the first item (temperature rise) the object of considerable research work, which is considered well repaid by the satisfaction that it will result in the conservation, during this year, of several million pounds of copper that would otherwise have entered into the construction of radiators. The subject is most important to our discussion, but involves such a mass of detail that I will deal with it only briefly in its relation (1) to water delivery and (2) to air velocity. We have a physical law, that the amount of heat given off from a source is proportional to the difference in temperature between the radiating body and the air, and other authority states that the loss of heat by convection is nearly proportional to the difference in temperature between the hot body and the air. This being true, we are concerned in maintaining the surfaces in a radiator at as high an average temperature as is practical, and this, of course, in our case is directly a function of the rate of water circulation. It becomes a matter then of choosing a standard for circulation that will give practical pump sizes and still maintain a reasonably small temperature drop through the radiator. With this in view, I propose as a standard that rate of circulation which will give a temperature drop to the water circulated through the radiator of not more than 15 deg. fahr. From Equation VII then, we get

$$\text{Pounds water circulated per min. per hp.} = \frac{100}{15} = 6.67$$

$$\text{Gallons water circulated per min. per hp.} = 0.8 \quad \text{(XI)}$$

This would give a circulation per minute of 16 gal. for a 20-hp. engine, 24 gal. for 30 hp., etc.

Effect of Circulation

Fig. 2 will serve to illustrate the effect rate of circulation has on cooling capacity. In the first radiator water enters at a temperature of 200 deg. and is circulated at the rate of 200 lb. (about 24 gal.) a minute, leaving the radiator at 180 deg. The heat given up amounts to 4000 B.t.u. per min., and the average temperature of the radiator surfaces is 190 deg.

In the second case conditions are the same except the circulation, which is only 100 lb. per min., requiring a 40 deg. drop to get rid of the same amount of heat as in the first case. The fan is not drawing any more air, consequently, in order to absorb the same amount of heat as in the first case, the average temperature of the surfaces must be maintained at 190 deg., which requires an entering water temperature of 210 deg. and leaving of 170 deg.—or all the difference, with the same radiator, between satisfactory cooling on the one hand and boiling on the other.

The relation of temperature rise of the air to velocity of the air over the heated surfaces will have to be treated briefly with the statement that, as we get up into the velocities practical for our purpose, the heat

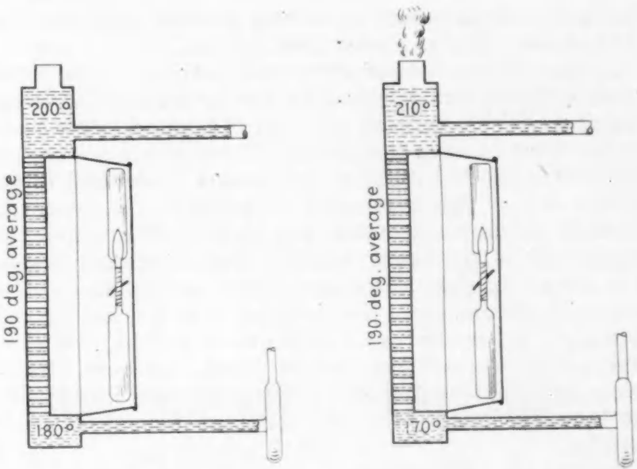


FIG. 2—EFFECT OF RATE OF CIRCULATION ON COOLING CAPACITY

Air Velocity

taken up by convection increases nearly directly in proportion to the velocity. This is illustrated by the temperature rise curve, Fig. 3, which is typical of the temperature rise characteristics of almost any type of radiator, as well as the thickness of radiator core. The only limit that we are bound by in air velocities is the power available to effect the velocity, but with this in view as well as further remarks to follow, I would propose a standardized air velocity referred to gross radiator core area of 2000 ft. per min. This velocity is practical with most of the radiator types on the market and, as applied, will meet nearly all requirements up to 50 hp. in space available for radiator mounting. The matter of a definite value for the factor $(T_4 - T_3)$ concerns the characteristics of design of each type of radiator core and its thickness, but most of them intelligently offered for tractor work will be able to meet the requirements of a 30 deg. rise with initial, or operating temperature of 100 deg., air velocity of 2000 ft. per min., maximum water temperature of 200 deg. and water circulation as suggested. I say "intelligently" as regards experience with the limitations of space available for radiator mounting. These assumptions meeting approval, Equation IX comes to

$$\text{Sq. ft. radiator required per hp.} = \frac{6000}{30 \times 2000} \times 1 = 0.1 \text{ for L-head engines.}$$

$$\text{Sq. ft. radiator required per hp.} = \frac{6000}{30 \times 2000} \times 0.8 = 0.08 \text{ for valve-in-head engines.}$$

From some fifty cases I have tabulated data as to rated horsepower (using the formula $\frac{D^2SN}{F} \times$ No. cyls., in which F has a value of 12,000 for valve-in-head and 13,000 for L-head types), actual radiator size, fan size, and fan speed in each instance. These cases I have divided into groups of varying horsepowers and averaged the data in each group. In applying the suggested formula for radiator size, I find that it would check well in the 20-hp. group if in a few of the cases the 18-in. fans were run at a higher speed than 1450 r.p.m. In the 30-hp. division L-head type the actual radiator size is about 12 per cent larger than that proposed by the formula, but the average fan of 19 in. diameter was driven at only an average speed of 1600 r.p.m. In the 30-hp. valve-in-head class the formula radiator size is about 3 per cent larger than actual sizes with average fan size 18.66 in. and average fan speed 1866 r.p.m.

In the 35-hp. L-head class the formula radiator-size is about 3 per cent larger than the actual size. Average fan size is 19.3 in. and average fan speed 1666 r.p.m. Some of the cases in this division, I know, are not cooling properly, and the division as a whole could well afford to use larger fan diameters. In the 40-hp. class the formula radiator-size checked with the actual size. One 50-hp. case, a well known tractor, gives formula radiator-size about 13 per cent larger than actual size. This tractor is considerably overpowered, but its cooling performance under average conditions is entirely satisfactory. I know, and its makers know, however, that a heavy full load boiling will occur, and they agree with me that the 13 per cent additional, as recommended, is justified.

One 64-hp. valve-in-head engine tested a short time ago has actual radiator size about 4 per cent greater than formula size, but the cooling capacity was found to be at least that amount in excess of requirements. As we get up into higher horsepowers, the space available to mount the radiator in becomes more and more an important factor, so that air velocities and fan speeds must be increased at the expense of added power for fan drive. This introduces an added variable in our formula and consequently the radiator size formula is not recommended for use above 50 hp. The basic equations may, however, be adapted to larger outputs.

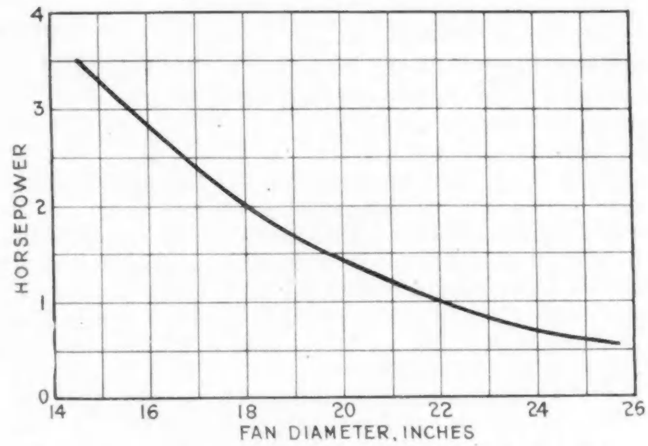


FIG. 4—HORSEPOWER TO DRAW AIR AT 7000 CU. FT. PER MIN. THROUGH RADIATOR

By the foregoing it will be seen that the problem of cooling is fundamentally one of how much air can be economically delivered through the radiator, and to what degree it can be economically heated. Granted efficient fans to choose from, it would seem that the first consideration should be the amount of power that we would be justified in using to effect the delivery. This available power could conveniently be expressed in terms of engine horsepower.

Fig. 3 shows air deliveries effected by a typical 20-in. fan at varying fan speeds, corresponding air velocities and power consumptions, the characteristics of each of which are typical of fans such as offered to the trade. It will be noted that the volume of air that can be handled and its corresponding velocity increase well in proportion as the speed increases, but it is evident from the power consumption curve that a certain point is reached in fan speed beyond which the power consumption mounts upward with astounding rapidity.

If it were not for this, we could deliver so much air through the radiator that there would not be much left for the radiator manufacturer to do, as the radiator cost curve indicates, but in this event, of course, the purpose of the tractor engine would be subverted to pulling wind instead of plows. On the other hand, the fan speed could be so low that the radiator cost would be abnormally high, and so our problem becomes also one of where to content ourselves along the power consumption line.

Consider for the moment a 35-hp. L-head engine; we find, from Equation VIII and using our standards, that volume of air for cooling required per minute is equal to

$$35 \times \frac{6000}{30} = 7000 \text{ cu. ft.}$$

From volume curve in Fig. 3, we would require a 20-in. fan to be driven at 1775 r.p.m. to effect this delivery. The power required would be about 1.5 hp. and the resulting velocity very nearly checks with our suggested standard of 2000 ft. per min. giving a radiator size of 35×0.1, or 3.5 sq. ft. The power

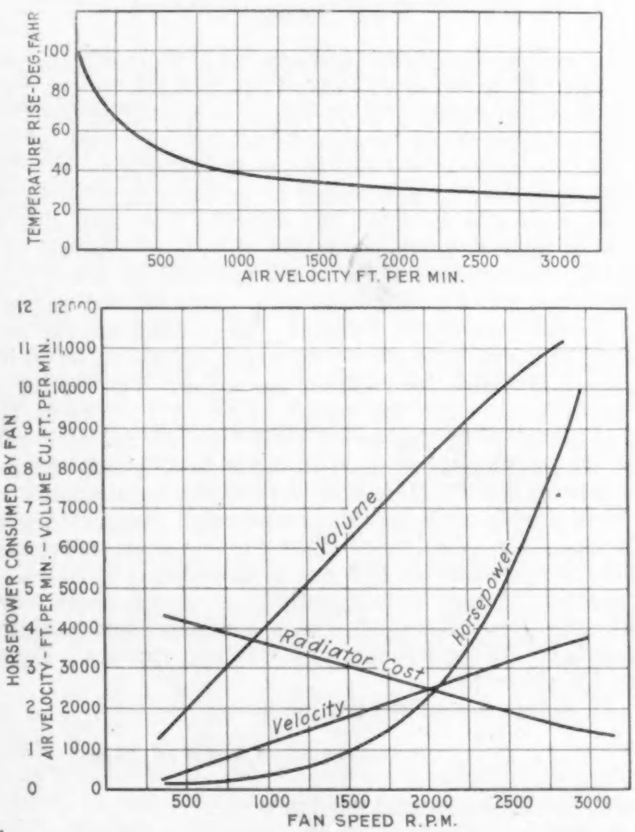


FIG. 3—UPPER DIAGRAM SHOWS RELATION OF TEMPERATURE RISE OF AIR TO VELOCITY OF THE AIR. LOWER DIAGRAM SHOWS CHARACTERISTIC CURVES OF A TYPICAL 20-INCH FAN AT VARYING R.P.M.

for fan drive, in this case, amounts to about $4\frac{1}{2}$ per cent of the engine power, a figure typical of prevailing practice.

Fan Power Requirements

Suppose, however, we had chosen a 22 in. fan in place of the 20-in. fan. From Fig. 4, showing power consumption of different size fans, each delivering about 7000 cu. ft. of air per min. through a radiator, we find that whereas it requires 1.5 hp. to deliver 7000 cu. ft. of air with a 20-in. fan at 1775 r.p.m., it would require only about 1 hp. for a 22-in. fan to deliver the same volume at 1400 r.p.m. If the fan and the radiator were properly incorporated in the tractor design from the beginning instead of being thrown on somehow or other at the last minute, 0.5 hp. or 0.375 lb. of fuel could be saved for each hour of engine operation. If the tractor is operated 1000 hr. per year., the saving with fuel at 20 cents per gal. would amount to $12.00 per year; assuming that this saving could be applied to only 100,000 tractors, it is certainly worth conserving.

In my recommendations below for fan sizes, therefore, I have in mind larger fans and slower speeds than those in present average practice and propose that power consumption for air deliveries should not be more than 3 per cent of formula rated engine power. Although this is a subject that could be dealt with more intelligently by the fan manufacturer, I believe that the following table showing recommended fan sizes and fan speeds will about meet the suggested power limitation requirements:

Engine Hp.	Fan Hp.	Air Cu. Ft. per Min.	Fan Diam., In.	Fan r.p.m.
20	0.60	4,000	18 (Narrow blade)	1,600
25	0.75	5,000	18	1,600
30	0.90	6,000	20	1,500
35	1.05	7,000	22	1,400
40	1.20	8,000	24	1,400
50	1.50	10,000	26	1,400

In making this plea for larger fan sizes and slower speeds, I have in mind not only economy of operation, but also alleviation of a number of annoyances such as lubrication, bearing troubles, belt slippage and breakages—all too familiar, and all incident to high fan speeds and overloading.

While I have touched on the fan question only lightly, it is one that, as applied particularly to the tractor industry, should be well worth the attention and study of our fan manufacturers and I hope that the leaders will be far sighted enough, in uncovering their trade data, to give us full and open information on the subject.

In conclusion, if I have been able to demonstrate that cooling troubles are not always the fault of the radiator, and if I have convinced the members of the desirability of adopting some degree of standardization of the essentials of cooling, I shall feel satisfied.

Effects of Low Temperatures on Starting

By O. W. A. Oetting* (*Member of the Society*)

Cleveland Section Paper *Illustrated with* Photograph and Charts

THE starting troubles encountered because of cold weather conditions are most exasperating to the car user, but in the majority of cases are avoidable if all the effects of low temperatures have been anticipated by the automobile designer. The proper application of the electric starter and storage battery for use on passenger cars, auto trucks and tractors presents problems to the engineer which, if properly solved, will prevent some of the troubles which frequently have occurred in the past.

No apparatus is required to operate under such a variety of conditions as the automobile engine and its accessories. The range of temperature from the heat of summer to the freezing cold of winter is one of the conditions that must be appreciated in making the proper application of the storage battery for this service. Storage batteries that will operate satisfactorily under these extreme conditions can be made, but engineers must take into consideration certain existing facts. In cold weather, the capacity and the voltage of a battery are less than at normal temperatures. Likewise, it is much more difficult to start an engine because of the effects of these cold temperatures on the lubrication and also on the carburization of the fuel. In addition to these facts, we find that the efficiencies of the electric starting motors are considerably lower at the low cranking speeds encountered under these cold weather conditions. *The factor that must be used in determining the size of the storage battery is the power required to start the engine under these cold weather conditions.*

Considerable data on cold weather starting have been secured. It is the purpose of this paper, first, to give a short résumé of these tests and, second, to summarize these results so as to predict, if possible, the size of storage battery that is required for starting any engine, giving the approximate ampere-hour battery capacity in terms of the piston displacement of the engine.

Battery Sizes

Heretofore, not enough attention has been given to the size of storage battery required on a car and almost invariably a smaller size of battery has been used when a larger battery would have given better service. This haphazard application of the battery shows great inconsistencies when a plot is made of the battery sizes against the engine displacements, as shown in Fig. 1. The data for this plot are taken from a list of all the 1917 passenger cars and are no doubt representative of present-day practice. It can be seen that the 80 ampere-hour battery is used on cars having piston displacements from 95 to 425 cu. in. On the other hand, the 100 ampere-hour battery is used on cars with displacements ranging from 170 to 425 cu. in. Undoubtedly, cars with piston displacements over 200 cu. in. should be equipped with a larger battery than 80 ampere-hours and those with displacements greater than 250 cu. in. should have a battery larger than 100 ampere-hours. The foregoing plot is true of course, only if the gear ratios between the

*Engineer, Willard Storage Battery Company.

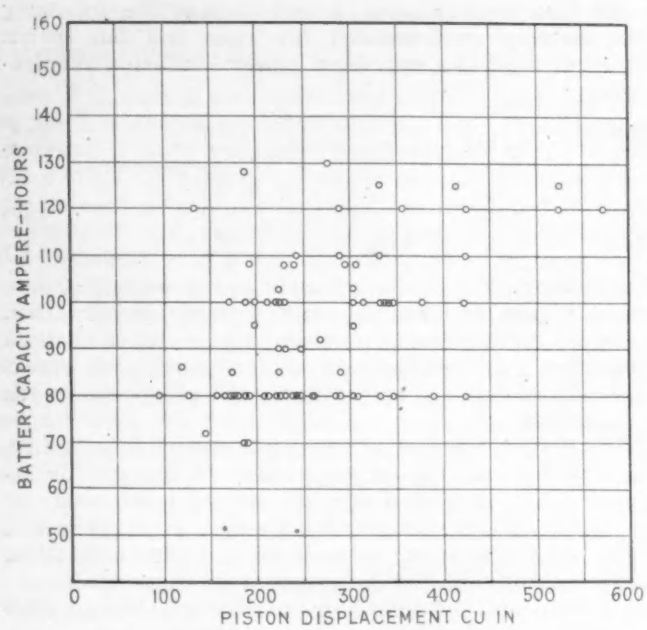


FIG. 1—COMPARISON OF SIZE OF STORAGE BATTERY WITH ENGINE DISPLACEMENT ON 1917 PASSENGER CARS

starter and engine are the same. On present-day makes of cars this is practically so, inasmuch as the majority of the cars are equipped with the single-gear reduction with ratios approximately equal to 10 to 1.

With the purpose in mind of securing some factor that will determine definitely the size of battery required for every size of car, engines were tested with their starting motors and batteries in a large refrigerator to find the actual power required to turn over the engine at various temperatures. The exact minimum of temperature at which the engine should start promptly is of course debatable.

Average Low Temperatures

Fig. 2 shows a chart which was compiled from data on temperatures obtained by the U. S. Weather Bureau. The figures within the circles are averages of the temperatures during the three winter months observed for a long series of years at various stations throughout the United States. The small figures beside the circles give the absolute minimum temperatures at the same localities during this period of time. It will be noted that only three states have an average temperature lower than 10 deg. fahr. If then we take 10 deg. fahr. as a cold weather standard and design the engine and all the automobile accessories to operate properly at this temperature, little trouble should be experienced during the winter months and satisfactory service from the apparatus will be assured.

One of the effects of low temperature on a storage battery is to lower the terminal voltage, especially at the high rates of discharge that are required by the starting motor. Fig. 3 shows the "five-second" voltage curves of a 100 ampere-hour battery at 80 deg. fahr. and at 10 deg. fahr.

By the term "five-second voltage" is meant the voltage that a battery will give at the end of five seconds at a certain discharge rate of current. In other words, the battery represented by Fig. 3 will have a voltage of 4.82 after five seconds discharge at 400 amperes at a temperature of 80 deg. fahr. It will be seen from this curve that this battery would not be suitable for an engine with a starter requiring 300 amperes at 4.5 volts when the tem-

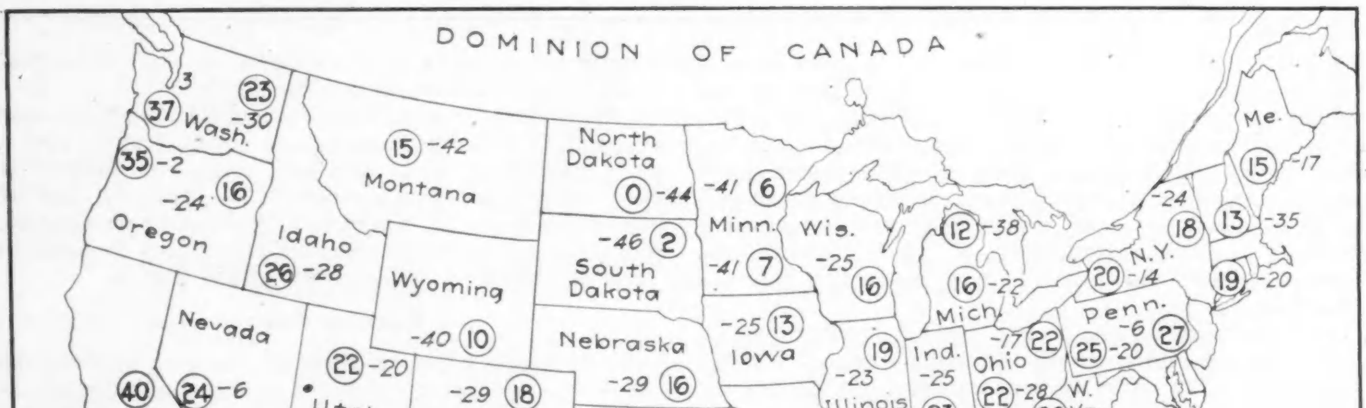


FIG. 2—AVERAGE TEMPERATURES IN VARIOUS LOCALITIES THROUGHOUT U. S. DURING THREE WINTER MONTHS
Note: Small numbers beside circles give absolute minimum temperatures.

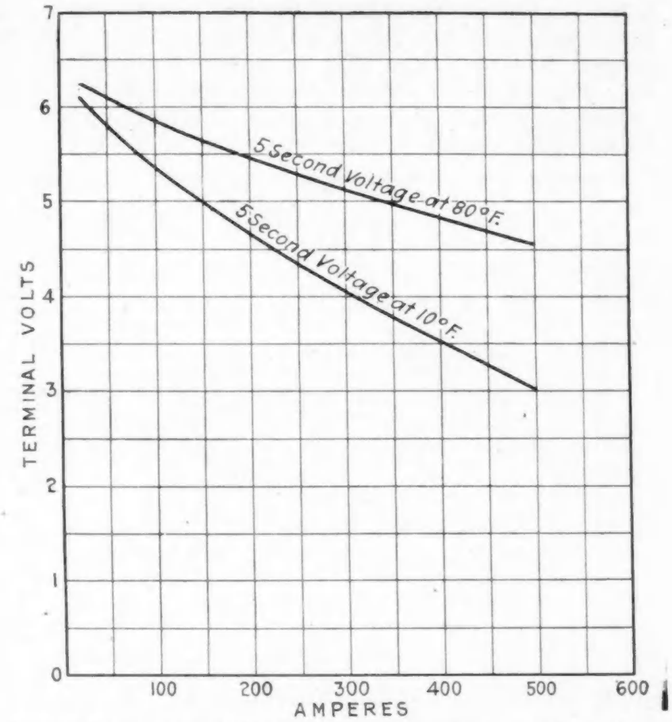


FIG. 3—COMPARISON OF VOLTAGE CHARACTERISTICS OF 100 AMPERE-HOUR STORAGE BATTERY AT 80 DEG. AND 10 DEG. FAHR.

perature was 10 deg. fahr. or lower. Curves such as these should be used in all starting motor designs.

Fig. 4 is a picture of a refrigerating machine and cooling chamber used for testing an automobile engine with its starter and battery at low temperatures. This refrigerator can be cooled to a temperature as low as 30 deg. The engine to be tested is placed within the box and wires are brought out from the battery and starter to read the electrical input required to start the engine at low temperatures. A thermometer and some anti-freeze solution are placed in the cooling chamber of the engine and the temperatures can be observed from the outside of the box by means of a small observation door in the main

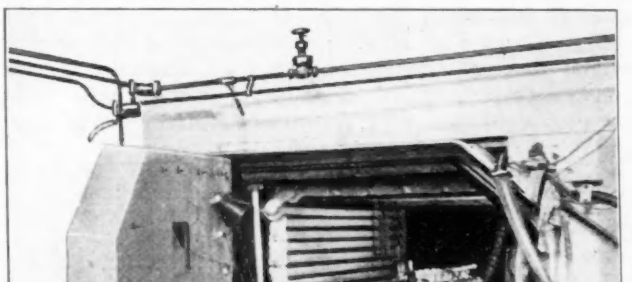


FIG. 4—REFRIGERATOR USED FOR TESTING ENGINES FOR COLD WEATHER STARTING CHARACTERISTICS

door of the box. The revolutions of the engine are obtained by means of an electrical contactor, which rings a bell outside of the refrigerator. After the starting data are obtained at the normal room temperature, the box is slowly cooled to any desired temperature and the starting characteristics of the engine at this temperature are then observed.

Test Results

Table I gives the results of a test on a four-cylinder engine having a piston displacement of 171 cu. in. The values in this table give the power that is required to break away the engine and then roll it at a certain speed and temperature. These results are plotted in Fig. 5, the curves showing the average power used for the

TABLE I—POWER REQUIRED TO BREAK AND ROLL 4-CYL. ENGINE

Motor Volts		Amperes		Watts			
Break	Roll	Break	Roll	Break	Roll	Speed, R.P.M.	Temp., °F.
4.75	4.0	200	175	950	700	61	60
5.20	5.0	260	175	1350	875	130	60
5.90	5.75	210	180	1240	1035	162	60
4.15	3.60	245	275	1020	990	42.5	30
4.60	4.25	280	270	1285	1150	57	30
4.70	4.25	260	280	1220	1190	65.5	30
4.50	4.25	275	285	1240	1210	66.5	30
5.60	5.10	260	265	1510	1350	83.5	30
3.90	3.4	310	280	1210	950	24.5	10
3.70	4.2	290	310	1075	1300	31.5	10
3.90	4.2	315	300	1230	1260	33	10
5.80	4.5	335	330	1950	1485	43	10
6.10	5.5	380	390	2320	2140	71.5	10

Figures in columns headed "Break" are the instantaneous readings taken the moment the circuit closed.
Figures in columns headed "Roll" are the average readings taken while the engine was rolling.

break-away and roll of the engine at various engine speeds and temperatures. The engine in this test had one cylinder which required about 50 amperes more than any one of the other three cylinders during the roll of the crankshaft. This, however, is the service that is demanded of a new storage battery on a car, as the engines often are not "run in" sufficiently before shipment is made by the car manufacturer. A 90 ampere-hour battery at a temperature of 10 deg. fahr. turned over this engine at a temperature of 8 deg. fahr. at 30 r.p.m.

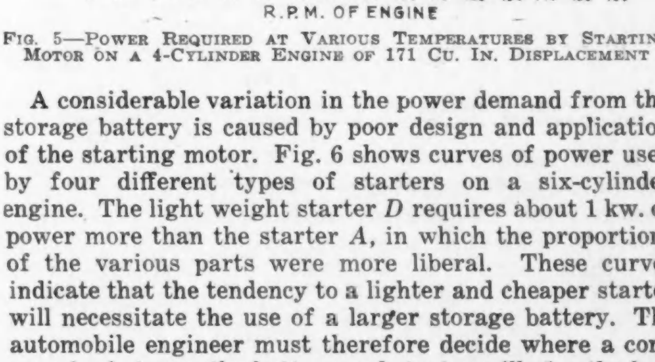


FIG. 5—POWER REQUIRED AT VARIOUS TEMPERATURES BY STARTING MOTOR ON A 4-CYLINDER ENGINE OF 171 CU. IN. DISPLACEMENT

A considerable variation in the power demand from the storage battery is caused by poor design and application of the starting motor. Fig. 6 shows curves of power used by four different types of starters on a six-cylinder engine. The light weight starter *D* requires about 1 kw. of power more than the starter *A*, in which the proportions of the various parts were more liberal. These curves indicate that the tendency to a lighter and cheaper starter will necessitate the use of a larger storage battery. The automobile engineer must therefore decide where a compromise between the battery and starter will give the best economy and service. In the case of the engine in question, starter *B* was used. At 30 deg. fahr. this starter with a 120 ampere-hour battery rolled the engine at a speed of 30 r.p.m.

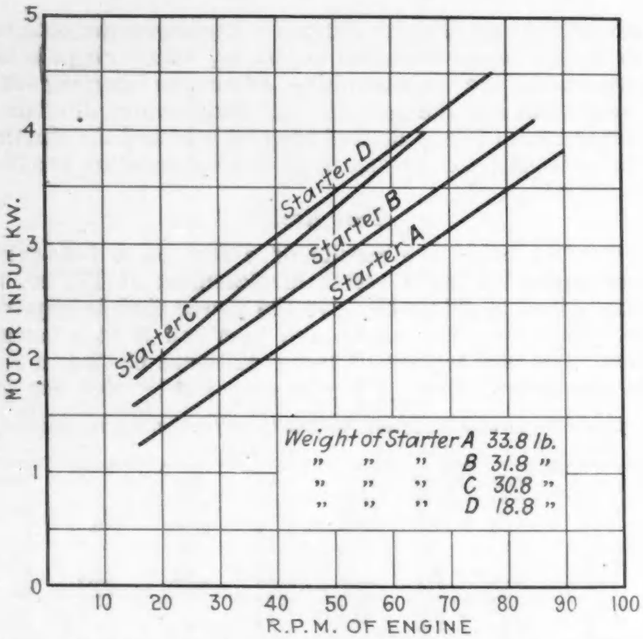


FIG. 6—POWER REQUIRED AT 10 DEG. FAHR. BY DIFFERENT TYPES OF STARTERS ON A 6-CYLINDER ENGINE OF 268 CU. IN. DISPLACEMENT

In Fig. 7 corresponding curves are shown on an 8-cylinder engine having a displacement of 332 cu. in. This engine was made by a well known engine manufacturer and the fittings of all the parts were well made. The results on this test were therefore lower in proportion to the size of this engine as compared with some of the other engines tested at these cold temperatures.

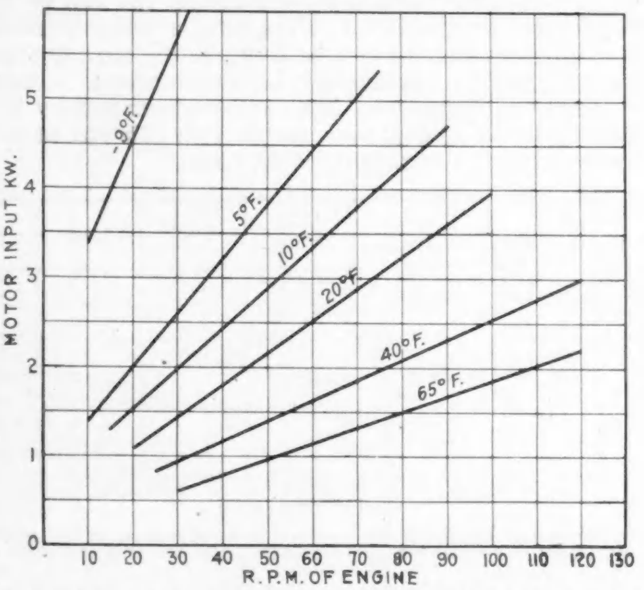


FIG. 7—POWER REQUIRED AT VARIOUS TEMPERATURES BY STARTING MOTOR ON AN 8-CYLINDER ENGINE OF 332 CU. IN. DISPLACEMENT

A bad feature in the design of bearings was brought out in one of the cold temperature tests during these investigations. The bearing caps on one of the engines tested were made of aluminum, and at the low temperature these bearings were found to be shrunk tight on the shaft, due to the difference in the coefficients of expansion of the two metals. During the test, it was observed that this engine required an unusually large amount of power to start it. The pistons, connecting-rods and camshaft drive were therefore removed; the power required to turn the crankshaft and flywheel was found to be considerable. Fig. 8 shows that the power required for this latter condition was about one-third of the total power required to break-away and turn the engine without the pistons removed. At 6 deg. fahr. with the pistons removed and 2.8 kw. supplied to the starter it was impossible to pry the engine loose with a 10-in. lever in the teeth of the flywheel. The results of this test gave values that were

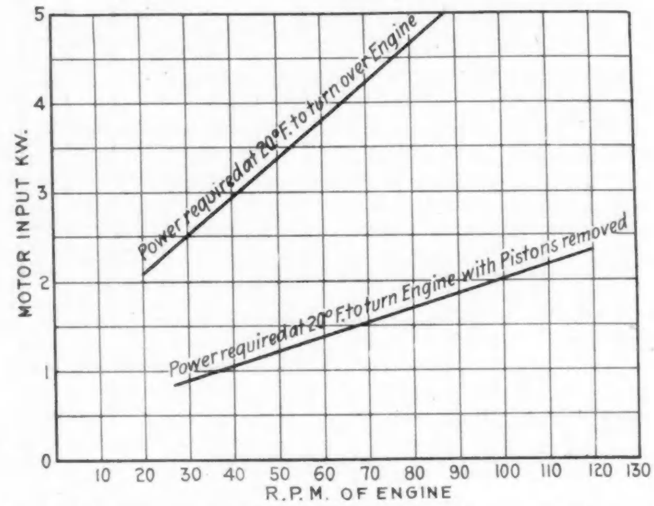


FIG. 8—COMPARISON OF POWER REQUIRED TO TURN A 6-CYLINDER ENGINE OF 303 CU. IN. DISPLACEMENT BEFORE AND AFTER REMOVING PISTONS AND CONNECTING-RODS

about 100 per cent higher than the average of all the engines tested under these cold weather conditions.

SUMMARY OF TESTS

Other engines in addition to those mentioned in the foregoing were tested and all the results were averaged so as to determine, if possible, the power required to start any size of engine. It was found that it is hardly possible to lay down a hard-and-fast rule for this purpose, but a close approximation is possible. Average results on the engines tested differed for various reasons, such as variation in compression, difference in viscosity of the lubricating oils at low temperatures, variation in refinement in the fittings of the engine, and difference in design of the starting motors.

Fig. 9 and Fig. 10 give a summary of the power required to start the various sizes of engines at normal temperatures and 10 deg. fahr. respectively. These curves are plotted with the axes of motor input against

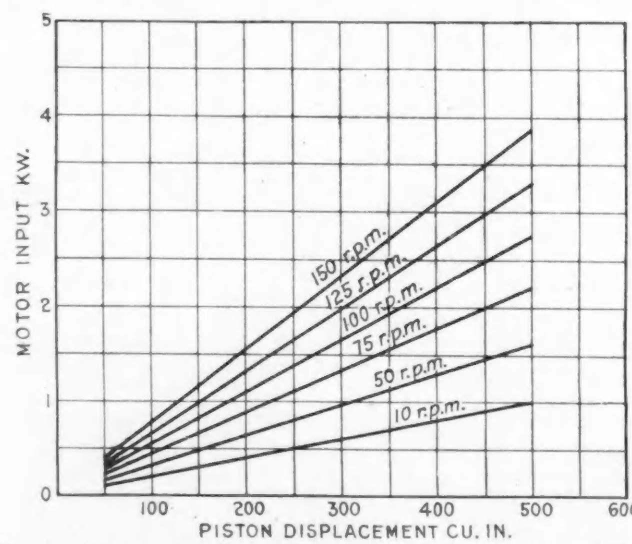


FIG. 9—APPROXIMATE POWER REQUIRED TO BREAK-AWAY AND TURN OVER VARIOUS SIZES OF ENGINES AT NORMAL TEMPERATURES

the piston displacement of the engine. It would have been more logical perhaps to have plotted the power used against the area of the rubbing surface of the piston walls, but this relation did not average the points any better than the one shown in the curve. For convenience, then, the coordinates used in the curves were chosen.

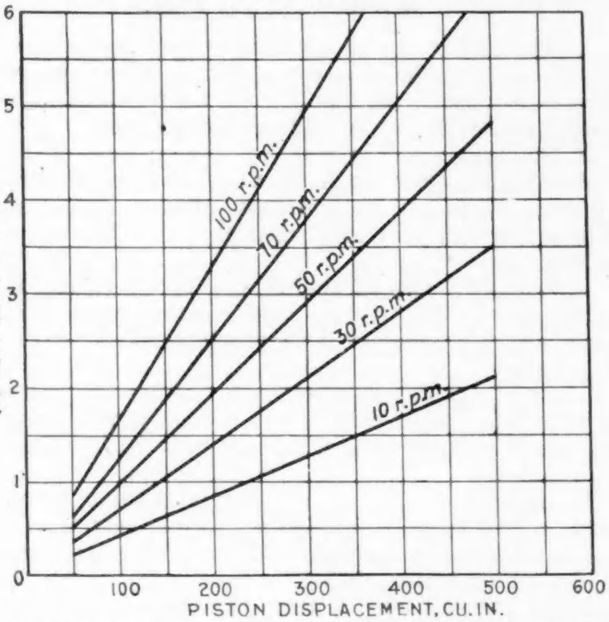


FIG. 10—APPROXIMATE POWER REQUIRED TO BREAK-AWAY AND TURN OVER VARIOUS SIZES OF ENGINES AT 10 DEG. FAHR.

Having ascertained now the power that is required to start the engine, but one more step is necessary to determine the approximate size of storage battery that is needed for this service. Fig. 11 and Fig. 12 show the "five-second voltage" curves of various sizes of batteries

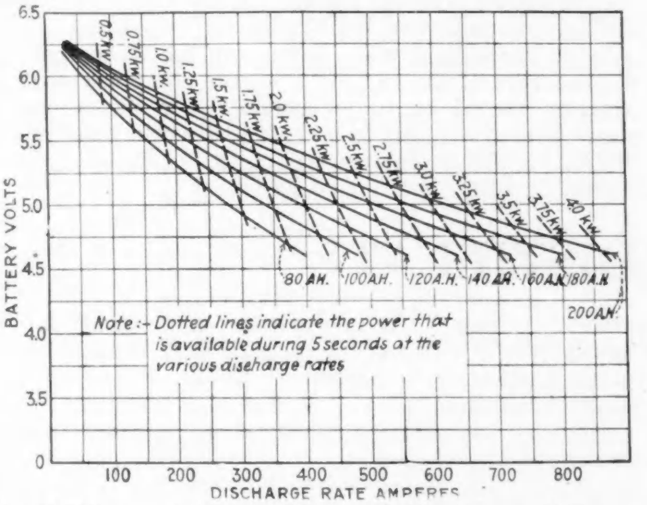


FIG. 11—VOLTAGE OF VARIOUS SIZES OF BATTERIES AFTER 5 SECONDS' DISCHARGE AT 80 DEG. FAHR.

at 80 deg. fahr. and 10 deg. fahr. respectively. The power that is available for five seconds from any of these batteries is the product of the volts and the amperes at any of the intersections of these coordinates. The dotted lines on these curves represent the power that can be obtained from any of these batteries for a period of five seconds. From these curves it is possible to determine the amount of power that a given size of battery will deliver when discharged at a certain rate of current or else discharged at some predetermined terminal voltage.

From these curves and the results of the engine tests it is possible to estimate the cranking speed of any size

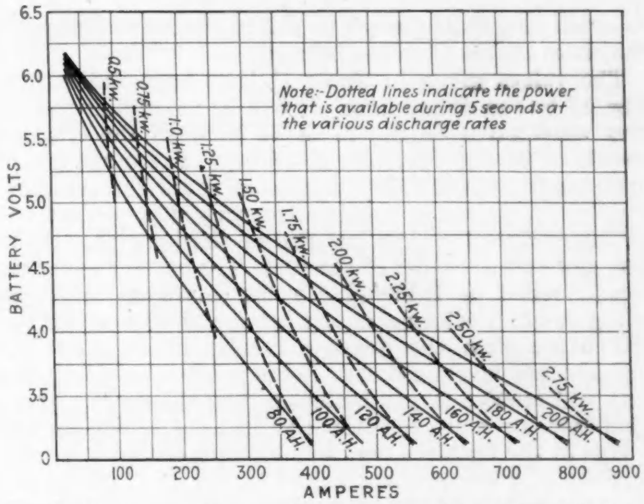


FIG. 12—VOLTAGE OF VARIOUS SIZES OF BATTERIES AFTER 5 SECONDS' DISCHARGE AT 10 DEG. FAHR.

of engine with a given battery at a temperature of 10 deg. fahr. when it is equipped with a 6-volt starter with a gear ratio approximately equal to 10 to 1. This has been done in the curves of Fig. 13, which show the average results of the engine speeds at 10 deg. fahr. with the

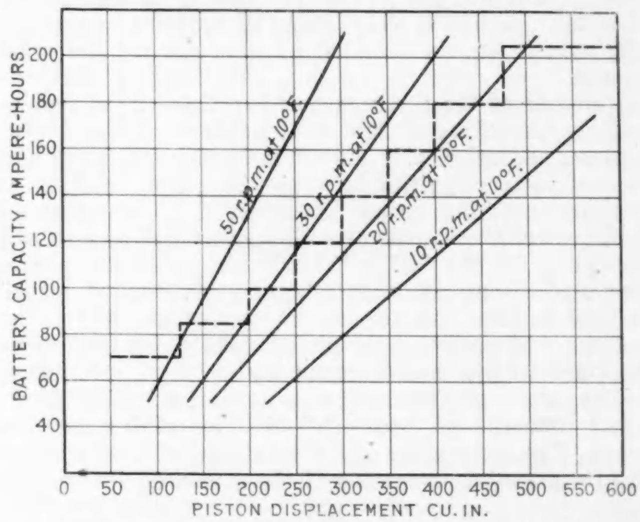


FIG. 13—MINIMUM BATTERY SIZES FOR SATISFACTORY STARTING SERVICE FOR 6-VOLT STARTERS. GEAR RATIOS 10:1

size of storage battery plotted against the size of the engine. Table II gives the minimum size of battery that is satisfactory for use on a 6-volt starting system when

TABLE II—MINIMUM BATTERY SIZES FOR STARTING SYSTEMS

Engine Size Cu. In. Displacement	Battery Size Ampere-Hours
Up to 125	70
125 to 200	85
200 to 250	100
250 to 300	120
300 to 350	140
350 to 400	160
400 to 475	180
475 to 600	205

For 6-volt systems with gear ratio approximately equal to 10 to 1.
For starting systems of higher voltage or gear ratios greater than 10 to 1, the battery size can be reduced proportionally.

the gear ratio is approximately equal to 10 to 1. The basis for these data is the power that is required by the starter at 10 deg. fahr. as shown in Fig. 10 and also that power which is available at this temperature from the battery when the rate of discharge is about four times its twenty-minute rate. No allowance was made for the drop in the leads or starting switch between the starter and the storage battery. This drop varies in the different applications from 0.2 to 0.5 volts and should be made

as small as possible, so as to utilize the maximum power that is available from the battery.

The values given in Table II have been indicated in Fig. 13 by the dotted lines. It will be noted that the battery sizes given in the table lie between the cranking speeds of 20 and 50 r.p.m. at 10 deg. There are diverse opinions in regard to the minimum speed for successful starting, a condition which necessarily depends not only on the electrical system but also on the ignition, lubrication and carburization of the fuel. The battery capacities recommended in Table II are the *minimum* sizes that will give satisfactory starting service at 10 deg. fahr. in accordance with the average results of all these low temperature investigations. Some engines may be found that will require larger batteries than these sizes and in such cases greater capacities should undoubtedly be used.

One of the features that was brought out very forcibly in these cold temperature tests was the effect of the cold on the viscosity of the lubricating oils. As the temperature decreases, the viscosity increases and causes a much greater resistance to turning. One certain grade of oil became a solid mass at these cold temperatures. A medium grade of oil in another test was found to have the consistency of extra heavy oil when cooled to 10 deg. fahr. Therefore, a light or a medium grade of oil of a quality that will not lose its lubricating properties at 10 deg. fahr. or hinder the successful operation of the starting system should be used on cars during the winter months.

Another of the features noted in these investigations, namely the effect of low temperatures on the ignition system, showed clearly one of the reasons for the adoption of battery ignition in place of magneto ignition. At the low cranking speeds encountered under these cold weather conditions, the cranking speed was seldom rapid enough to fire the fuel in the cylinders when the magneto was used. However, when a battery of sufficient capacity is used to turn over the engine successfully, the battery voltage will always be high enough to fire the engine equipped with a well-designed battery ignition system.

The grade of fuel and also its carburization have a great influence on successful starting at low temperatures. The installation of a good electrical system will be utterly negative in results if the grade of fuel or poor carburization keeps the engine from firing. If the electrical system turns over a cold engine at some reasonably high speed, it should be unnecessary for the car user to be put to the inconvenience of heating the carbureter and manifold of the engine to cause the ignition of the fuel.

Author's Conclusions

1. The size of a storage battery for starter service is determined by the power required to start and roll an engine at some reasonably cold temperature (10 deg. fahr.) at a sufficient speed to cause ignition.

2. Starting troubles may be due to lack of battery capacity, improper application or lack of size of the starter, viscosity of lubricant at low temperatures, faulty ignition, poor carburization, or an inferior grade of fuel.

3. A good design of engine and its accessories should take into consideration all of these causes and provide for satisfactory starting at a temperature no higher than 10 deg. fahr.

4. At 10 deg. fahr. the available battery capacity is approximately 50 per cent of the normal capacity and the voltage at this temperature also is reduced to a considerable degree.

5. At 10 deg. fahr. the efficiencies of the starting motors vary between 10 per cent and 40 per cent for the low cranking speeds encountered at these cold temperatures. A design of motor should be used which gives better starting torques and higher efficiencies at these low speeds, even if it is necessary to sacrifice the speed at which the motor spins the engine under normal temperatures.

6. A convenient double-reduction gearing between the starter and the engine flywheel can be made that will give better starting characteristics under cold weather conditions than a single-gear reduction.

7. A good quality of lubricating oil and a good grade of fuel are requisites for satisfactory starting.

8. As there is a wide divergence in the design and manufacture of the various automotive engines, each application should be tested separately to determine the power that is required to start it under cold weather conditions. In the absence of such data, the approximations derived in this paper should be useful.

CALIFORNIA "DISTILLATE"

In response to an inquiry from the Society, the Bureau of Mines of the Department of the Interior has stated that the petroleum product manufactured in California and marketed extensively in the West under the name of "distillate" or "engine distillate," is obtained as follows:

The crude is heated or "topped" in various types of stills or topping plants until the vapors reach a temperature of 400 to 500 deg. fahr. The condensed vapors, "tops" or "first-run distillate," are rerun in steam or combination steam and fire stills, yielding the following products in the order named:

- Gasoline.
- Engine distillate.
- Stove oil.
- Steam still bottoms.

In most cases, the engine distillate is agitated with a sufficient quantity of concentrated sulphuric acid to make it water white, and then washed with caustic soda and water before marketing.

Hence distillate or engine distillate is a refined rerun product coming between gasoline and kerosene. Its gravity is as a rule very close to 50 deg. Baumé (0.7796 sp. gr.) although a 52 deg. distillate (0.7711 sp. gr.) is also marketable.

Following are data of two typical samples of engine distillate:

Engler Distillations

Sample No. I. Gravity 51.4 deg. Baumé. (0.773 sp. gr.)

Temperature Fahr.	Temperature Cent.	Per Cent Distilled Over
216-250	102.2-121.1	32.5
250-300	121.1-148.8	49.0
300-350	148.8-176.6	14.5
350-390	176.6-198.8	2.5
Bottoms (trace of yellow)		0.8
	Total	99.3

Sample No. II. Gravity 50.1 deg. Baumé. (0.779 sp. gr.)

203	95	Initial boiling point
203-212	95-100	Trace
212-257	100-125	22.6
257-302	125-150	52.7
302-347	150-175	17.9
347-388.4	175-198	4.2
Residue		1.6
Loss		1.0
388.4	198	Final boiling point

Vol. II February, 1918 No. 2

Commercial Future of Aircraft

By WILLIAM B. STOUT* (*Member of the Society*)

MID-WEST SECTION PAPER *Illustrated with* CHARTS

A NUMBER of things must happen to the airplane before it becomes a thing of everyday travel. That this day will come, and very soon after the war period, is my belief, and one's fancy cannot, I believe, conceive of the changes that air travel will work on our national and international life.

Before attempting to describe the changes that will come about it will be necessary to establish some fundamentals regarding the work we are to do. First, our public must be made safe. Second, it must be made comfortable. Third, it must be transported from one place to another with advantage over other means of travel either in speed, lower cost, or comfort. Fourth, it must be given a mental attitude of receptiveness toward the new transportation.

As in the early days of the automobile, safety is the first thought of the public in relation to the new air transportation, and hence must be considered first.

The things that bring safety in aircraft are many, and will take development. When all are available, air travel will be safer per mile and passenger than any other form of travel. I say this with conviction, and believe analysis will bear me out. Not all of the safety factors have to do with the machine or engineering as we know it. I will touch on the engineering factors first, however.

Ninety per cent of the danger in present-day flying, as shown by statistics, is in the landing. There are almost no failures of parts in the air since we have found the weaknesses and faulty figuring of the early days, when to fly at all was equivalent to joining the suicide club. The landing then should come in for extended study, that there may be a minimum of danger during this small period of time. This danger is tied up in three major things: the speed of the plane when it lands, the roughness of the ground, and the space within which the machine may easily be landed and brought to a stop.

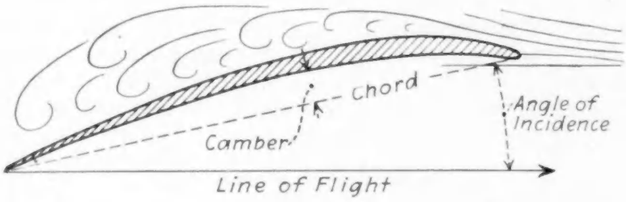


FIG. 1—AEROFOIL, SHOWING WIND STREAM AT STEEP ANGLE (HEAVY LIFT)

The first item of landing speed is a direct function of the design of the plane, and so I shall digress a little and discuss some of the fundamentals of plane design that relate to range of performance.

Airplane Fundamentals

An airplane is nothing more than a kite of scientific form. For a certain pull on the kite string—known as "drift"—one can make the kite lift a certain weight of tail papers, the weight depending on the "lift" of the kite surfaces. The best kite is the one that will give the most lift with the least kite-string pull; and likewise the best wing curve is one that will give the most lift with the least drift.

Fig. 1 shows a deeply curved wing, with the nomenclature of the curve given. Imagine this wing in flight at the steep angle shown, the line of flight being in the direction of the arrow. There is a pressure of air beneath the surface, through the wing's forcing a change of direction in its flow, but there is also a partial vacuum above, forming the greater factor in the lift of the wing at these steep angles.

Wing Curves

For the steep angle of flight shown in Fig. 1 the deeply curved wing is the proper thing. This curve means lift, and for bombers and heavy lifting planes deeply curved aerofoils are used, but they are not suitable for speed. When one crowds on power to make them fast, or attempts speed by cutting down surface, the condition shown in Fig. 2 obtains, the air at the flat angle of incidence which the plane takes at high speeds banking up in front of the wing in eddies like a bow wave in front of a canal boat. The wing curve shown is a "freighter" curve.

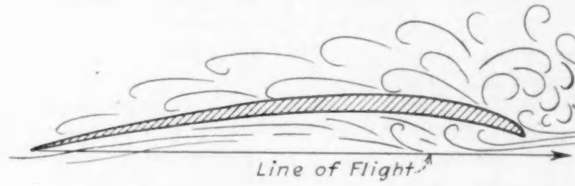


FIG. 2—SAME CURVE AT SPEED, SHOWING BOW WAVE

In Fig. 3 is shown a wing that slides through the air at flat angles with little resistance and no bow wave, but its lift per square foot is low. The deep-curved wing may lift 10 lb. per sq. ft. and the speed-curve not more than 5. Here, however, is where the plane beats the boat, for surface can be added in the wings with the low-lift curve until its maximum lift equals that we had with less surface with the high-lift curve, and by crowding on power we can get high speed, while still retaining our old original slow-landing speed. It is by this method that planes have been perfected for getting off the ground at around 45 and flying up to 125 m.p.h.

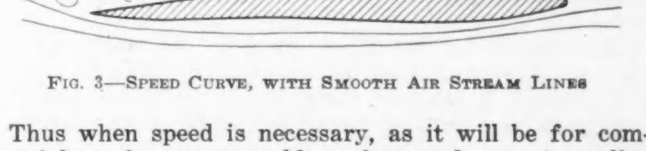


FIG. 3—SPEED CURVE, WITH SMOOTH AIR STREAM LINES

Thus when speed is necessary, as it will be for commercial work, we can add surface and use streamline curves and get the very necessary speed range. This is not all, however. The wing that has the greatest lift with the least drift—or resistance to forward travel—is

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all things considered the most efficient wing. This drift is in lifting planes a large factor in power consumption, but it forms only a fraction of the head-on resistance to forward flight known as head resistance.

Parasite Parts

Head resistance is of two kinds: drift, which is useful, and parasite resistance, which is useless.

The resistance of the wings to progress is necessary to get lift. Overcoming this resistance allows the plane to fly. However, the resistance of the plane body, the wires, struts and all exposed parts, is only lost work and does not contribute to supporting the plane. At 60-mi. speeds the parasite parts are not of major importance; at speeds of over 100 m.p.h. they are the dominant hindrance.

In the type of construction used in the Caproni one can easily see where most of the power would go were this type forced to high speeds, as the number of parasite parts is enormous. At bombing speeds it is very effective, but not efficient enough as at present constructed for the commerce of the future.

Landing

Landing speed alone does not solve the safety item. With the large surface plane there is a light wing loading, so that when the power is shut off it "floats" for a long distance. If we dive to get to the ground quickly we pick up speed quickly. What then is the use of slow-speed landing if it takes twice the space to land with a floater machine? After we touch the ground, too, this machine takes a long time to stop. Machines of heavy loading and fast landing are able to land in ball parks. The pilot is in danger, however, at the time he touches the ground at speed, but the machine quickly slows down. In the end one type is about as dangerous as the other, for safety requires ability to land at the slowest possible speed, in the smallest possible space, and on the roughest possible ground. We can land at slow speed, and in small space, but not with the same machine. The third item may give a clue to further study, that of landing on rough ground. Present machines have high landing gears, demanded by the necessary propeller clearance at the front of the machine. The whole machine, for this reason, lands, as one might say, on stilts. The center of weight in planes is high, and when the wheels strike really rough ground the action of the wind on the tail surfaces is the only means of keeping the machine from somersaulting; and this pressure gets less and less as the plane slows down.

Safety in Speedy Flying

For safety in landing means should be devised for carrying the weight low without interfering with the flying qualities of the plane. If the weight could be low, and the body as near to the ground when one lands as a motor car body, then the danger of nosing over would be small, and a high-speed landing could be made in small space on rough ground in safety. Allowing higher landing speed with safety would permit designers to increase maximum air speed so that there would be benefit all around.

Once in the air the faster one goes the safer he is, as he has stronger hold on the medium in which he travels, and is less influenced by the prevailing winds. Speeds of 200 m.p.h. will probably occur within the next year.

Variable Wing Curves

The commercial plane may go a step further than I have indicated—and here is real opportunity for inventors—by developing planes with variable wing curves. Then we can get off the ground with a deep curved lifting wing for climbing and when we have reached our altitude we can flatten the curve out into a speed section, and flit away as fast as we please. When we want to land we can then have slow speed with the possibility of landing in small space, and on rough ground. The development of this type of wing will probably be the next basic step in the development of the airplane.

As the use of aircraft develops there will be established at all cities landing fields smoothed off and marked with the direction of the wind, so that there will be plenty of space to land in and no rough ground. The use of the ideas described will add to safety, however, and in case one is flying a single-engined machine he will still have the ability to make emergency landings in safety.

Safety Factors

The coming of the multi-engined plane will eliminate the necessity for landing at other than prepared fields, and for commercial work two or more engines will be the rule and the one-engined plane the exception. With this type of plane and the prepared fields, with instruments for flying, and with skilled pilots, the safety part of air navigation can be considered as settled. Emergency landings nowadays are rare, and getting rarer. Almost all accidents are to student pilots under forced training who attempt feats before they are fitted for stunt work. In the hands of skilled men flying, even today, is safe.

Comfort

Having worked out the safety factor we come to comfort. For this engines must be muffled and away from the passengers. There must be no noise nor smell from the machinery. If the engines are not actually muffled the exhaust must be led to the rear, where the passengers will not hear it.

Passengers also must be totally inclosed out of the wind. They must be comfortably seated and warmed and enabled to see the country over which they are flying. They will be amused by wireless communication as they go along. The interior of the cars must imply safety and comfort, that nervousness may be a minimum. It may even be necessary to keep the air pressure in the passenger compartment normal on account of weak hearts at flying heights. All these things will come, and more which we do not even imagine.

Steering by Wireless

The instruments for making the course accurate will be of new type. There will probably be certain established wireless wave length lines flowing between cities. A certain wave will float between wireless stations at New York and Chicago. In the plane will be a needle which will always point in the direction of this wireless wave, so that the pilot, through fog or rain or storm or totally inclosed in the cabin, can follow the line accurately as though strung on a cord. With this and a barograph the plane can laugh at storms.

We must also consider the speed of the machine in the air as a direct factor in making aircraft an eventual means of transportation. When we learn how to build planes for heavy-lift, high-speed performance—and we are very near to it—we will be able to do with heavy bombers what we do now with speed scouts, and with machines designed for transportation of many passengers do feats which today the speed-scout trickster could not attempt if he would.

I must be pardoned if this whole talk consists of generalities very largely, as it is evident, without further

explanation, why I can give no details. There is no reason, however, to prevent my stating rather definitely what I think we shall see after the war in commercial constructions.

Predictions

I can see planes of present horsepower carrying twice the weight they carry to-day, and at 200 m.p.h. I can see flights from coast to coast with but one stop, and with many passengers. I can see the crossing of the Atlantic an accomplished fact, not as a single trick, but as an everyday method of travel, and the trip made from daylight to dark, or, better, from dark to daylight—steering by the stars and wireless.

Where there are water crossings requiring much rehandling, I can see the transportation of certain kinds of freight by air. Where railways are roundabout, I can see real hauling of heavy weights, such as ore, or borax, from Death Valley, carried by plane. It will not be long before the camel on the Sahara will be as much out of a job as a trotting horse in Detroit, while planes become the new ships of the desert. Almost all passenger, mail and light express work between London and coastal continental cities will be by air. Even today there are tons of airplane parts per week flown over the channel as air freight for the front. It is quicker and cheaper and the material "gets there." Such a delivery might save a business battle as well as a military one.

I would not attempt to discuss the commercial future of the airplane by quoting figures on upkeep, gas cost, depreciation, etc. No one knows today what the actual running cost of a freight or passenger plane would be. We are at the kite stage of airplane construction. Two years from now we will laugh at what we now call a modern airplane. The industry is changing too fast. At the same time one may pick up the cards and tell what is in the trick.

There is no engineering reason why it should take more power and gasoline to carry seven passengers at 60 miles an hour over a road and up a 10 per cent hill than to do the same on wings. With the same power one should be able to do twice the speed and accomplish double the same climb. It is probable that the plane will show more economy per mile than a motor car, and, in big planes for long hauls, beat out the train for passenger cost.

When this is done, and we can collate and analyze the cost figures, we will see lines emanating from every American metropolis in everyday commercial work. We will take a taxi at breakfast time, do four hours' business in New York and be back for dinner at 8 in the evening. Some of us may have our own aerial jitney and drive to work and back, though I fear this is far in the future.

Many will not agree with some of the broad statements I have made. I do not expect that they will. Things never go just as we think they will, but as the cards read today all is propitious for the early use of airplanes in extensive commercial work—after the war.

SOCIETY DINNER AT KANSAS CITY TRACTOR SHOW

The second dinner of the Society to be held during the Kansas City Tractor Show took place Feb. 13 at the Hotel Baltimore, Kansas City. Nearly 200 members and guests of the Society were in attendance.

Chairman Dent Parrett of the Tractor Division of the Standards Committee acted as toastmaster of the occasion, while a number of other speakers addressed the diners regarding the relation of S. A. E. activities with the tractor industry.

Dean W. M. Jardine of the Kansas State Agricultural College, speaking for the Kansas State Council of Defense, stated that tractors must work 150 days instead of 50 days each year in order to compensate for the large number of farm boys who will be taken by the draft. He recommended that manufacturers end tractors to the farms on a rental basis, particularly in July, the vital month, when it is too hot to use horses.

J. B. Bartholomew, president of the National Tractor Manufacturers Association, stated that the greatest need now was railroad cars in order to make tractor deliveries. Many of these factories were stocked with tractors but no railroad shipping facilities are available to make deliveries now when it is imperative that the southern states receive tractors immediately.

The way in which tractors were used at the defense of Verdun was explained by Captain F. M. Monroe, of the Engineer Corps of the French Army, who is now an instructor at Fort Funston, Kan.

Other speakers were First Vice-president David Beecroft, chairman of the Meetings Committee of the Society; E. J. Sweeny, Standards Manager M. W. Hanks, A. P. Yerkes of the U. S. Department of Agriculture, Prof. G. A. Young, head of the school of mechanical engineering at Purdue University; H. L. Thompson of the Moline Plow Company, Guy Hall of the Kansas City Tractor Club, and Mr. Peake, of the Kansas City Automobile Dealers' Association. A complete report of this meeting will be published in the next issue of The Journal.

An exhibit of the standards work of the Society was made at the Tractor Show, and resulted in considerable interest being shown by the visitors. The Class B military truck engine naturally received the most attention, but the tractor standards work of the Society was the subject of many inquiries.

Vol. II February, 1918 No. 2

Factors Governing Small Tractor Design*

By ALAN E. L. CHORLTON (Non-member)

Illustrated with CHARTS

THE problem of providing mechanical power to replace that of the horse in the most suitable and efficient form for the purposes of agriculture is one of no inconsiderable difficulty, the guiding factors being such variables as the size of the farm, the class of land, the nature of crop, road transportation, and the financial ones of first cost and annual charges. The information relating thereto is so diverse, so variable and difficult to relate to actual fact (it seems more often a matter of opinion rather than fact) that the mechanical engineer investigating the problems on lines he is accustomed to finds himself at some loss where to begin, and is driven, in the end, owing to this lack of precise information, to provide much of the essential data by actual experiment.

Undoubtedly there is, apart from the actual mechanics of the problem, a considerable divergence of opinion as to the manner in which the problem should be met, while agriculturally the views held are seldom accompanied by those proofs upon which any engineer would rely. The difficulty of bringing together the agricultural expert and the mechanical engineer is a real one. This difficulty is reflected in the tardy progress in this country (England) of mechanical agricultural science, which, apart from the conservatism of the farmers themselves, has undoubtedly depended upon the cut and dried methods so familiar in the past, and not upon scientific and technical research, the need for which at the present day is so prominently before us.

Although in the main the views held by farmers can be divided into two groups—those who favor a special power implement for each purpose, and those who think a general-purpose machine should be provided to deal with each and all—yet the problem should undoubtedly be considered, in the first instance, from the standpoint of capital expenditure and annual charges. The average farm in this country is comparatively small, and the farmer may find it financially impossible to purchase a special power-driven implement for each of his requirements, even should he be of opinion that such a policy is a desirable one. For example, if a light tractor were purchased for plowing alone, then a powerful unit would be needed for threshing, while on the road provision must be made for the mechanical power required for transport.

A fourth power unit may even be required for other purposes; thus a first cost of say £350 ($1,705) per unit might be increased approximately to £1,050 ($5,115) or even to £1,400 ($6,820), while the yearly writing off of capital and interest would be increased proportionately, each requirement now having to bear the full charge of its special machine. The effect on the working costs of the writing off of so large a capital expenditure, incurred by uni-purpose machines, is very material. For example, the capital charges for a tractor costing £350, suitable for plowing alone, and allowing seven years' life and 100 acres per year, would be 10s. ($2.23) per acre, for 200 acres 5s. ($1.12) per acre, and even if an allowance is made for performance of light land work, subsequent to plowing, the cost would probably amount to 3s. ($0.73), equivalent to the cost of fuel (at 3 gal. per acre), and as great as, if not greater than, the wages of two operators.

The financial consideration of the problem brings out the advantages of a multi-purpose machine, a power unit—if it could be designed—to meet the majority of calls of the farmer, instead of a special power implement for each purpose. Such a desirable combination should never be lost sight of in any general investigation of the fundamental factors of design.

Though beginning with the general aspect, the progress of the investigation revealed the extent of the field covered by the application of mechanical power to agriculture as too wide for the scope of this paper and the time at the disposal of the author, and it was, therefore, in the end, as the financial aspect was considered so important, narrowed down in the main to a consideration of the possibilities of a single power unit that would meet the majority of the demands called for on the farm. There will always be farms so large, or special conditions of such a nature, as to allow of the purchase of special machines for each purpose with commercial advantage; such cases, however, must be considered individually, and are not dealt with here. There is no doubt, however, that despite the questionable soundness, from a commercial point of view, of the use of many special-purpose units for the average farm, there still remains a strong body of opinion that the use of such power implements is the right thing, and only the showing of the future, when the farmer has purchased on these lines, will clearly demonstrate whether due consideration had been paid to the financial aspect of the problem.

It is essential to bear in mind the incidence of the duties called for from the tractor; will they so fall as not to conflict? That is to say, can the uses of such a power unit be reasonably well divided to cover the agricultural year with the help of horses, that will be always available to a limited extent? It is held that they can, though each farmer must, with his own conditions in front of him, judge for himself. The requirements called for from a power unit during the agricultural year are:

(a) Plowing, dragging, rolling, drilling.
(b) Reaping, binding and leading.
(c) Threshing, pumping, pulping, chaff cutting and grinding.
(d) Transport work to the station.

These duties are not likely to take more than 70 per cent of the total working days of the year.

It is not possible here to consider these operations in further detail, for we must confine our examination to the mechanical factors of the problem. The three principal uses which, by their requirements, govern the design of the tractor, are:

(a) Road work—transport.
(b) Land work—plowing.
(c) Farmstead—threshing, etc.

(a) governs the minimum axle loading, (b) governs the maximum axle loading, (c) governs the minimum power required.

*This paper was recently presented before the Institution of Automobile Engineers at London.

1. Road Work—Transport

The basic factors governing the application of mechanical power for traction purposes are adhesion and resistance.

Tractive Adhesion.—The adhesion of the driving wheels on the road must be sufficient to utilize the power developed by the engine in overcoming the tractive resistance of the load and the tractor combined.

Considerable amount of data exists relating to tractive resistance, but for tractive adhesion on common roads little, if any, information can be found. For traction on rails the locomotive engineer has plenty of data, obtained by the use of dynamometer cars, and from these have been developed recognized constants. The standard figure of adhesion is 0.25; that is, one-quarter of the load on the driving axles can be used in drawbar pull. It is stated that this figure rises to 0.35, but it is not advisable to use such a value in practice.

As no adhesion values were available for steel tires on common roads, experiments have been made to determine them. In these experiments a steam tractor towed a loaded wagon by means of a recording dynamometer. In order to obtain maximum results the experiments were extended so as to traverse a steep hill, and even with this additional resistance it was still necessary to apply the brake to the wagon before the maximum value was exceeded and slipping began.

It will be seen clearly that these experiments also afforded an opportunity of testing traction-resistance constants, and this was done.

To make the results still more useful the same tractor was fitted with rubber-tired wheels and tested under similar conditions. The whole forms a useful combination of data for the designer of tractors for common roads, and the author is beholden to Messrs. Ruston, Proctor & Co. for enabling the tests to be carried out. These results are shown in Table I and in Figs. 1 and 2.

From these it will be seen that the maximum value—with slipping just beginning—for steel tires is 0.56, and for the rubber tires 0.6. It is suggested that in practice,

Table I—Typical Results for Various Surfaces

Test No.	Kind of Road	Condition of Road	Location	Traction Resistance Total	Traction Resistance Per Ton
29—30—31	Concrete (unsurfaced)	Smooth, excellent	Near Davis	83.0	27.6
*11—12	Concrete (unsurfaced)	Smooth, excellent	Near Davis	90.0	30.0
26—27—28	Concrete (3/8-in. surface asphaltic oil and screenings)	Smooth, excellent	Near Davis	147.6	49.2
13—14	Concrete (3/8-in. surface asphaltic oil and screenings)	Smooth, excellent	Near Davis	155.0	51.6
9—10	Macadam (water-bound)	Smooth, excellent	Near Davis	193.0	64.3
22—23	Topeka on concrete	Smooth, excellent	Near Davis	205.5	68.5
8	Gravel	Compact, good condition	Near Davis	225.0	75.0
†45—48	Oil macadam	Good, new	Near Sacramento	234.5	78.2
‡46—47	Oil macadam	Good, new	Near Sacramento	244.0	81.3
33	Gravel	Packed in good condition	Near Davis	247.0	82.3
18—19—20	Topeka on plank	Good condition, soft, wagon left marks	On Causeway, near Davis	265.0	88.3
34	Earth road	Firm, 1½ in. fine loose dust	Near Davis	276.0	92.0
24—25	Topeka on plank	Good condition, but soft	Near Davis	278.0	92.6
1—2—3	Earth road	Dust ¾ to 2 in.	Near Davis	298.0	99.3
3—4	Earth	Mud, stiff, firm underneath	Near Davis	654.0	218.0
6—7	Gravel	Loose, not packed	Near Davis	789.0	263.0

*Graphic record indicates that the load was being accelerated when the test was stated.
†Drawn with motor truck at 2½ miles per hour.
‡Drawn with motor truck at 5 miles per hour.

when country roads have to be taken into account, a safe value for steel tires would be 0.45, and 0.55 for rubber tires, or 0.5 if long life of tires is desired. This means, in effect, that in getting out the design of the

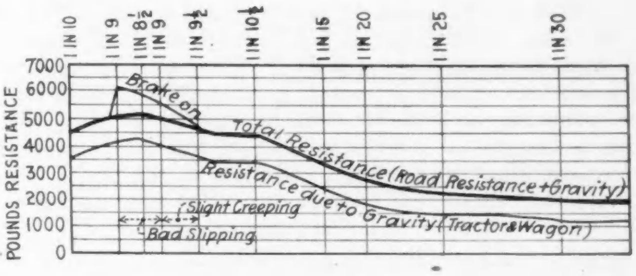


Fig. 1—Results of Road Resistance and Adhesion Tests with Steel Tires on Driving Wheels

Tractor, gross weight, 7.4 tons. Wagon, gross weight, 8.7 tons. Complete train, gross weight, 16.1 tons. Weight on driving wheels (3 ft. 6 in. x 12 in.), 10,000 lb. Adhesion factor, without slip, 0.46. With slight creeping, 0.56. Max., 0.62. Road resistance per ton, av. 53 lb. Average speed, 1¾ m.p.h. Road surface, very good macadam, dry

tractor for road transport, a duty that limits the minimum weight, the propulsive effort cannot be taken as exceeding 0.45 times the weight on the driving axle for steel tires. The high cost of rubber tires for road purposes and the special wheels, seems hardly justifiable for the conditions obtaining on a farm.

Traction Resistance.—From the experiments, Figs. 1 and 2, the tractive resistance for a good macadam road comes out at just over 50 lb. per ton, the diameter of the rear wheels of the loaded wagon being 4 ft. by 9 in., that of the front 3 ft. 6 in. by 9 in., with steel tires. The values given in Table I are the results of experiments lately carried out over roads in California.

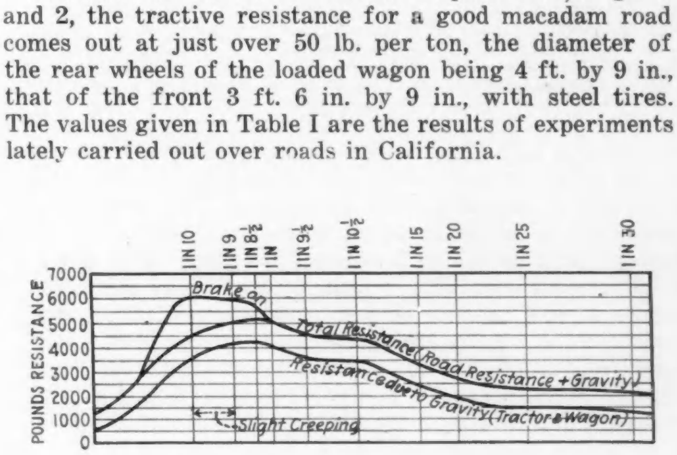


Fig. 2—Results of Road Resistance and Adhesion Tests with Rubber Tires on Driving Wheels

Tractor, gross weight, 7.4 tons. Wagon, gross weight, 8.7 tons. Complete train, gross weight, 16.1 tons. Weight on driving wheels (3 ft. 4 in. x 10 in.), 10,000 lb. Adhesion factor, without slip, 0.58. With slight creeping, 0.6. Road resistance per ton, av. 53 lb. Average speed, 1½ m.p.h. Road surface, very good macadam, dry

For the purposes of this investigation a value of 60 lb. per ton has been taken.

Having now the values for adhesion and resistance, it is necessary to inquire as to the load a farmer will require for road transport. As it is desirable that the tractor should work on the land with practically the same efficiency as a special-purpose machine, heavy axle loading is prohibited, and it becomes necessary to proportion the tractor weight to fulfill this condition, and yet permit of the requisite adhesion for hauling the load on the road.

When the tractor is hauling a wagon in ordinary service the load can be adjusted to any condition or gradient. Is there, however, any other governing condition in which this adjustment cannot be made? A load that is in one, so

to speak—and here a full-sized 4 ft. 6 in. threshing machine can be taken as a guide—such a machine weighs $4\frac{1}{4}$ tons, as a safe maximum say 4.5 tons.

The next consideration is the reasonable maximum gradient a tractor may be called upon to face. If a maximum gradient of 1 in 10, and a tractor weight of 50 cwt. (5600 lb.) is assumed, we have 224 + 60 = 284 lb. as the total resistance per ton. Then the total load of 4.5 tons plus 2.5 tons equals 7 tons, or a total propulsive effort of 1988 lb., which gives us, with a 0.45 traction adhesion, a load of 4400 lb. on the driving axle. With a tractor of a total weight of but 2.5 tons (say 15 cwt. on the front axle and 35 cwt. on the back), this axle weight cannot well be provided. The increased loading on the axle due to the reaction of the drive, the values of which are shown in Fig. 3, provides, however, a means of meeting this difficulty. The alternative method is to adopt artificial loading on the axle. Resolving the drawbar pull into engine power at 2 m.p.h., at 70 per cent gear efficiency the brake horsepower of the engine is 15.2, and at 80 per cent efficiency the power would be 13.2 approximately.

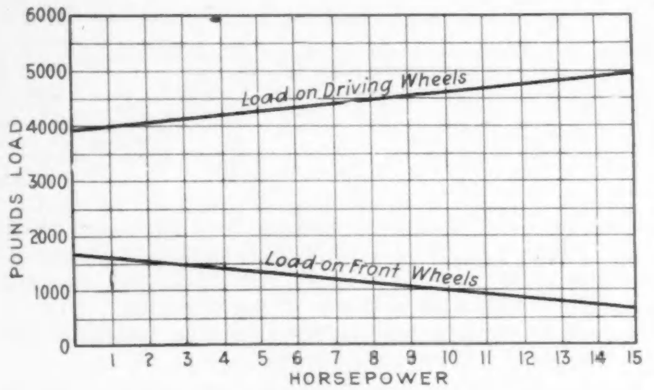


Fig. 3—Displacement of Wheel Loads Due to Turning Moment and Drawbar Pull

Weight of tractor in working order, $2\frac{1}{2}$ tons. Wheelbase, 6 ft. Dia. of driving wheels, 4 ft. Height of drawbar from ground, 1 ft. 8 in. Power lost in rolling resistance taken as 20 per cent

For still heavier loads or steeper gradients a larger power is required, and it is desirable, therefore, that this be provided, if not incompatible with the other factors.

2. Work on the Land

The factors governing successful working on the land are not easily determined, and apart from the difficulty of carrying out experiments such intangible things as the varying opinion as to allowable pressure on the soil must be taken into account.

Generally, however, weight is an important consideration, and must not exceed a certain maximum, while additional tractive effort in excess of that consistent with this weight must be obtained by other means, such as projections on the wheels or spuds.

The pressure that worked land will bear without injurious effect upon the crops varies according to the nature of the soil. From the mechanical point of view the limit of pressure is set by the necessity to prevent sinking into the ground, an occurrence seldom solely due to excessive weight.

What usually happens is that owing to inadequate gripping power the driving wheels rotate and act as milling cutters, scraping out the soil from beneath.

The relative values of weight and spud area are difficult to allocate so as to be able to make comparisons; for instance, a machine with a 30-cwt. axle loading and short spuds pulls partly by adhesion and partly by grip, and the latter is rendered more effective by the weight of the wheel holding the ground down during this action. On the other hand, a lighter tractor with 15-cwt. axle loading must pull largely by grip alone, and the effectiveness of the grip is modified and reduced by the lighter weight behind it and by the greater rolling resistance per ton set up by the spuds.

Hence the data to be ascertained are the proper relation of pressure on the land, the pressure against it, and the action of the rim projection, strake, spud or grouser.

We have thus three prime conditions to be met for the majority of cases:

(a) Driving axle loading,
(b) Pressure against grips or spuds,
(c) Effect of rolling resistance.

Considering first pressures that have been usual on land work, we have:

Man's shoes	8.5 lb. per sq. in.
Horse's hoofs	20 lb. per sq. in.
Cart tires—	
Load 2 tons	40 lb. per sq. in.
Gas tractor in use—	
3 tons on axle	25 lb. per sq in.
With extension	16 lb. per sq in.
Steam tractor—	
3.5 tons on axle	17 lb. per sq. in.

Assuming from our previous figure a static axle loading of 3920 lb., then with the driving wheels of the tractor 48 in. dia. by 12 in. wide, we get with a contact area of 288 sq. in. (sinkage of wheel $\frac{3}{4}$ in.) a pressure of 13.6 lb. per sq. in.

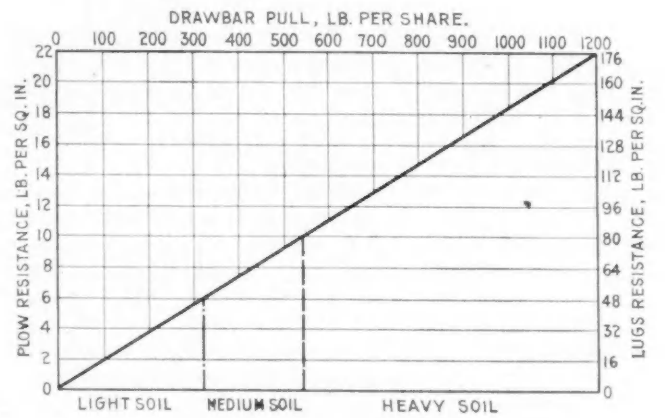


Fig. 4—Relation of Lug to Plow Resistance

The second part of the problem is more difficult owing to the absence of data, but concluding that the strength of the ground is represented by its resistance to plowing, Fig. 4 is useful.

Considering first pulling by grip alone (light tractors in Fig. 5a) the suggested allowable pressures against a spud are given, and for average land 50 to 75 lb. per sq. in. can be taken as corresponding to a plow resistance of about 9 lb. per sq. in. If it is assumed that the drawbar-pull is 2000 lb., and the loading 50 lb. per sq. in., the pull if taken by one spud in each wheel would be 1000 lb., so that for a wheel 12 in. wide the spud would be 1.67 in. long for average land.

For light lands when the strength of the soil is low, with the same drawbar-pull, this depth would have to be increased about four times, the spud would then be 6.7

in. long, based upon the relative resistance given in Fig. 4. This cannot be considered as a proposition to be recommended owing to the necessarily greatly increased rolling resistance of the tractor. A special device becomes necessary, such as an actuated spade, Fig. 6, fitted to the driving wheels, if efficiency is to be obtained. The mechanical complication and disadvantages of this method, even though they may be surmountable, are self-evident.

Many useful experiments can undoubtedly be carried out to determine the most efficient form of grip for varying conditions of soil and weights of tractor. On soft land the wheel tractor, either by reason of weight or

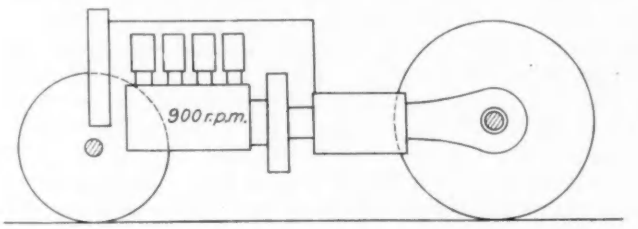


FIG. 5-A—REDUCTION REQUIRED FOR 2 M.P.H. 64 TO 1 APPROX.

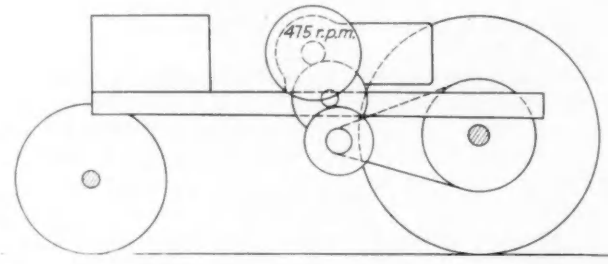


FIG. 5-B—REDUCTION REQUIRED FOR 2 M.P.H. 34 TO 1 APPROX.

spud pressure, is not suitable, and one of the track-laying type becomes essential. This, however, cannot be said to be at all necessary for the majority of English agricultural conditions.

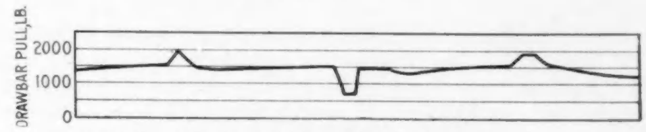
From the tests at 2 m.p.h. (see Fig. 7) when the drawbar-pull is 500 lb. per share, the curves in Fig. 8 have been got out; in these the important effect of gradient is indicated. For four shares and a gradient of 1 in 10 the load at the engine is 23 b.hp., and it is desirable that this should be obtainable if not inconsistent with the other governing factors of the design, for with four shares instead of three, 25 per cent extra plowing will be effected for the same cost of labor.

From the tests made in dragging the tractor, the 900-lb. drawbar-pull for a 3¼-ton tractor is equivalent to a rolling resistance of 277 lb. per ton on land. As the tests show, the loss in the gearing of the tractor is 32

TEST NO. 1

Plowing at 1.57 m.p.h. in stubble. Stiff clay land.
Mean drawbar pull, 2300 lb.
Mean drawbar hp. = 9.65 = 3.21 hp. per share.
Weight of tractor, 3¼ tons.
Weight of driving wheels, 5000 lb.
B.hp. of engine, 18.75.
Driving wheels, 4 ft. 6 in. dia., 15 in. wide.
Plow, Ransome 3-share, cutting 6 in. deep, 9 in. wide.

TEST NO. 2



Plowing at 2 m.p.h. in stubble. Medium soil.
Mean drawbar pull, 1500 lb.
Mean drawbar hp. = 8 = 2.66 hp. per share.
Rolling resistance of tractor with lugs on = 277 lb. per ton.
Power used in plowing = 8.0 hp. = 42.5 per cent of total hp.
Power used in rolling res. = 4.8 hp. = 25.5 per cent of total hp.
Power used in transmission = 5.95 hp. = 32 per cent of total hp.

FIG. 7—TESTS OF TWO-CYLINDER KEROSENE TRACTOR

per cent of the total power; had the gear of this tractor been constructed on the lines of automobile practice a considerably higher efficiency would have been obtained.*

From the other tests at 1.57 m.p.h. the drawbar-pull is 2300 lb., or 766 lb. per share, the drop in speed allowing

*"Scientific Determination of the Merits of Automobiles," by Dr. A. Riedler.

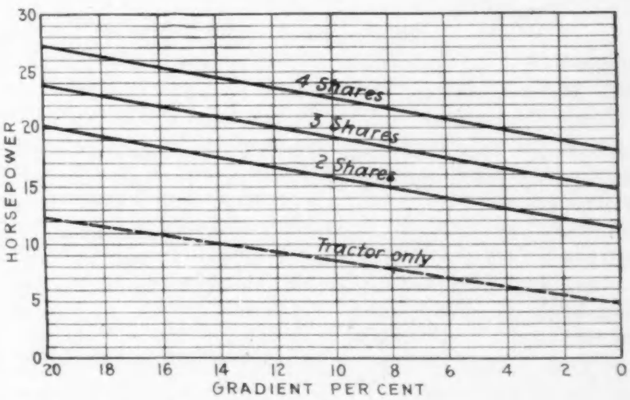
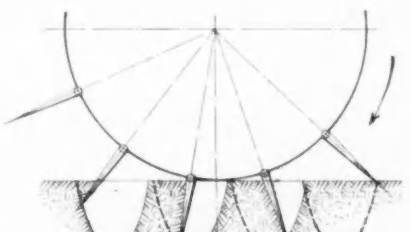
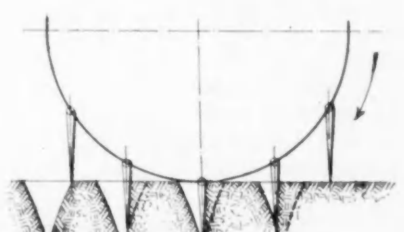


FIG. 8—POWER REQUIRED ON GRADIENTS PLOWING MEDIUM SOIL

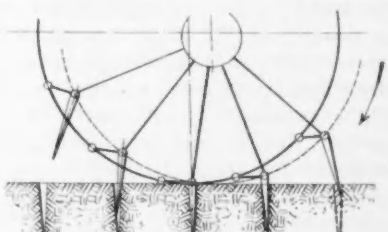
Weight in working order with 3-share plow, 3 tons.
Plowing speed, 2 m.p.h.
Rolling resistance of tractor with lugs on, 280 lb. per ton.
Furrows, 6 in. deep, 9 in. wide. Gearing efficiency, 80 per cent.
Pull required per share, on stubble ground, 500 lb.



EFFECT OF FIXED RADIAL PROJECTIONS, INDICATING LOSS OF POWER AND INCREASE OF TRACTION RESISTANCE



ACTUATED PROJECTIONS—PARALLEL MOTIONS



ACTUATED PROJECTIONS—ECCENTRIC OPERATION

FIG. 6

the engine to deal with the stronger land. The peakiness of this curve shows the value of large flywheel effort on the engine.

3. Work on the Farmstead

The highest power that a tractor when acting as a stationary power unit is called upon to provide is generally accepted as that for threshing.

Fig. 9 gives an approximate power curve for different sizes of threshing machines. From this it will be seen that 20 hp. is not exceeded, though it is usual to allow 25 hp. for large machines. For grinding, the powers required are less.

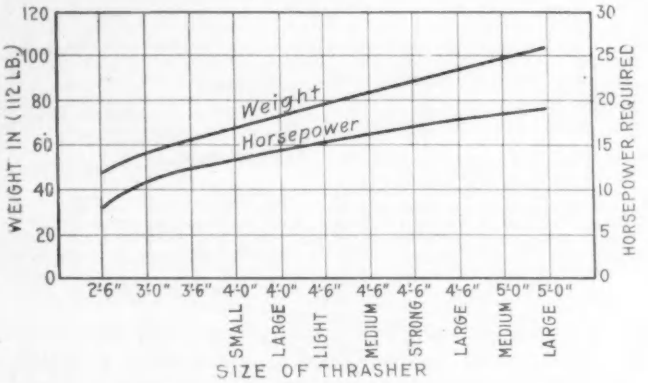


Fig. 9—Weight and Power to Drive Threshing Machines

Summing up now, and allowing a margin of safety on the results so far arrived at, the fundamental values for the multi-purpose tractor can be taken as:

	Hp. Required.	Driving Axle Loading.
Road work........	18 to 20	4400 lb.
Land work........	23 to 25	4400 lb.
Farmstead	20 to 25	Stationary

Although the following observations are not fundamental they form important considerations in the design of a tractor.

The Engine.—Any consideration of the engine must begin with the conditions under which it has to run on a farm, the inexpert attention likely to be given to it being an important factor. Generally, while this necessitates robust construction, it also calls for a low power rating or a considerable reserve of power, and probably the factors of low speed, large cylinder capacity for power required, strength and simplicity of parts are the main ones. That the engine must operate on paraffin (kerosene) is a *sine qua non,* and further, it preferably should develop its power without water injection.

The gain to be obtained by the use of crude oil in a high-compression engine would justify the greater refinement of the engine, though there is greater difficulty in obtaining the fuel, paraffin being probably the most universally and readily obtainable of all oil fuels. On the other hand, such an engine running on paraffin would probably use up to 30 per cent less, a material and important saving and one that should induce the engineer to persevere with this type; the fact that the automatic ignition of this type removes the risks of all electrical gear must be borne in mind. It should be quite possible, however, to secure better economies with the ordinary engine than are at present customary. It may be taken that the consumption in practice is 3 gal. per acre, often more, sometimes less. A 20-hp. tractor has probably an average load of not more than five-eighths of the maximum, or say 12.5 b.hp. (see dynamometer readings—3 shares, plus allowance for stoppages and headlands). Taking two hours per acre, this gives, say, 12 pints per hour or 0.96 pints per b.hp. This result is not at all a bad one, and is probably much better than what is actually taking place in day-to-day work when the tractor is run by an ordinary farm hand. It should be possible to cut it down to 0.85 pint per b.hp., or with a high-compression engine to 0.6 pint or even less.

The type of engine used, whether vertical or horizontal, would in practice largely depend upon the plant of the manufacturer, four-cylinder vertical engines being naturally adopted by the automobile engineer, whose factory is suited to that type; where factory considerations do not step in it might reasonably be claimed that the horizontal type is to be preferred. It has frequently been found in practice with vertical engines not possessing vaporizing devices in the engine cylinder, that some of the paraffin fuel passes the pistons and mixes with the lubricating oil in the crank-chamber, with a consequent thinning of the lubricant, which causes excessive wear on the main and crankpin bearings. It is not suggested that there are not many effective paraffin carbureters on the market, but rather that, despite these, with the class of labor available on the farm for operating the tractor, such action will frequently take place in starting up and on light load.

The horizontal engine gets over this difficulty inasmuch as excess paraffin will drain off through the exhaust valve before reaching the piston. A successful form of inlet valve is shown in Fig. 10. The hollow head, which is kept hot by the heat due to the cylinder temperature, is arranged so that the entering gases in passing at a high speed through the venturi will impinge upon the hot walls; this forms an effective and compact vaporizer, and at the same time being in an inverted form, it is self-draining.

It must not be forgotten that the hot bulb engine can work with tube ignition, thus cutting out the electric installation, which is of all parts of the tractor probably the least understood by the farm hand; incidently, the running cost is reduced, as petrol (gasoline) is not required for starting. Thus such an engine could be arranged to operate by tube with but trivial alteration, in case of failure of the electric ignition.

The water injection, so often found in the high-speed engine of the vertical type, cannot be said to be conducive to long life; it was tried years ago in gas engine practice and eventually dropped.

The vertical high-speed type can be and is manufactured at a less total weight, and this has been an additional reason for its use on light-weight tractors. It is, however, reasonable to ask whether, despite our being used to comparatively high-speed engines on automobiles and motor trucks in which the average load is low, and the quality of fuel and the attention good, a speed of 500 r.p.m. can be exceeded under the conditions of farm service, quality of labor, heavy plowing loads and paraffin fuel, without a more than proportionate risk in wear and tear. Fig. 5 shows diagrammatically the two types of tractor, of which there are, of course, many variations.

Further, it is considered desirable that full power should be obtained with a mean effective pressure of only about 50 lb. per sq. in., and that as in the horizontal type of engine the vaporizer should be in the cylinder head and allow of easy drainage for the use of low-grade fuels. In Fig. 10 a suitable arrangement has already been described.

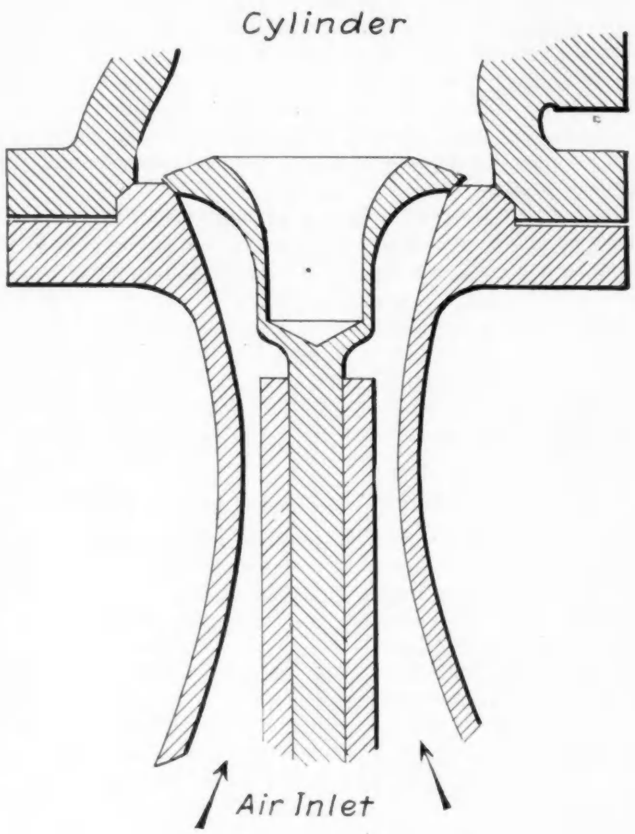


FIG. 10—KEROSENE VAPORIZER

It is true that with the high-speed engine the weight of the tractor is reduced, but in view of the necessity of giving a reasonably long life under the conditions of farm usage, it is debatable if this is a wise policy. A comparison with a light-weight tractor on a basis of cylinder capacity indicates that these tractors obtain their light weight per horsepower largely by high engine speed and rating.

Flywheel Effect.—It is desirable to arrange for ample storage of power in the flywheel of the engine to provide for the momentary excess required when meeting hard places, whereby the engine is subject to less strain, and the fuel consumption should also benefit. In the horizontal type suggested the flywheel effect is sufficient to provide 50 per cent power increase for about 30 seconds. In the light tractor with a quick-running engine there is usually considerably less power storage in the flywheel, and the engine must bear directly the extra demands and shocks.

Cooling.—Two methods are in vogue for cooling the

Type of Tractor	Weight, Lb.	B.HP.	Bore, In.	Stroke, In.	R.P.M.	ηp Lb. per Sq. In.	ηp Wt. Tons.	Vol. Swept per Min., Cu. Ft.	Vol. Swept per B.HP., Cu. Ft.	Vol. Swept per Ton Wt.
Four-cyl. vertical light.	3000	25	$4\frac{1}{4}$	$5\frac{3}{4}$	900	67	50	340	13.6	254
Two-cyl. horizontal multi-purpose..........	5600	28	$7\frac{1}{2}$	11	475	48	10	534	19	214

engine—in the one, the automobile system, a radiator, fan and circulating pump are used, and in general the whole conforms much to the standard practice in this respect. In the other system tank storage is adopted, the cooling of the engine being obtained through the loss of heat, due to evaporation from the open tank (the released latent heat, of course, effecting this).

The tank system is simple and is more foolproof in its working. It allows of almost any sort of water being used, such as is found in streams and drains about the fields, but on the other hand it needs considerably more make-up water than does the radiator system. The advantage of the radiator system is the much smaller quantity of water needed, so that if water is scarce the saving in cartage may be considerable. Its disadvantage is that the radiator itself may silt up or in some way develop leaks.

Both systems are used and probably local conditions will govern the choice.

Frame.—In the older type medium-weight machines as a rule a special frame was built up of rolled sections, while later, in order to save weight, the frame has been incorporated in the general design of the machine with advantage. This feature should undoubtedly be adopted in the design of a multi-purpose machine.

Gearing.—The typical forms of gearing for the two types of tractors are shown in Fig. 5. In one we have the design based on the automobile arrangement, using either bevel or worm gears, and with a high reduction on account of the high-speed engines, and in the other the design is based on that of the steam traction engine, in which neither the bevel nor worm is necessary; because of the cross-setting of the engine the latter type has not usually been totally inclosed. The total inclosing of the gearing and the running of the gears in oil baths, which originated in automobile practice, should undoubtedly be incorporated in the other design. As the test detailed in Fig. 7 indicated, the loss in the gearing is high, owing probably to the exposed gears, want of alignment under load and insufficient lubrication. When the horizontal engine type is built with all its gearing totally inclosed, the efficiency should be equal to automobile practice (see Riedler*). As the reduction is less, and as no bevel or worm is employed, it is not unreasonable to expect from the horizontal engine a higher overall efficiency than from the high-speed engine design. The advantages of ball or roller bearings in the reduction of friction losses are questionable. Published tests indicate but small bearing losses, so that any gain would be trivial.

Steering.—There are two types of steering (Fig. 11), the single and double pivot. The one is practically the standard in present agricultural machines, as steam tractors, etc., and the other is the standard in automobile practice.

The first is simple, cheap and strong in principle, and outside agricultural work, it is chiefly used in steam wagon practice. Yet despite this there is a general tendency to adopt the double-pivot system for small tractor work; this system, when centrally mounted so as to give three-point suspension, is to be preferred for the class of tractor under consideration.

Wheel Arrangements.—Fig. 12 shows some of the arrangements of the wheels of tractors on the market, for each of which the makers claim special advantages. The need for a tractor to be an efficient machine for road work, materially narrows the field of selection, and as long practice has proved that, for the power contemplated, the two-track four-wheel machine is the most suitable, this seems undoubtedly the one to be selected, as such a wheel arrangement is equally effective on the land.

The size of wheels may be 3 ft. by 5 in. for front wheels, and 4 ft. by 12 in. for rear driving wheels.

*"Scientific Determination of the Merits of Automobiles."

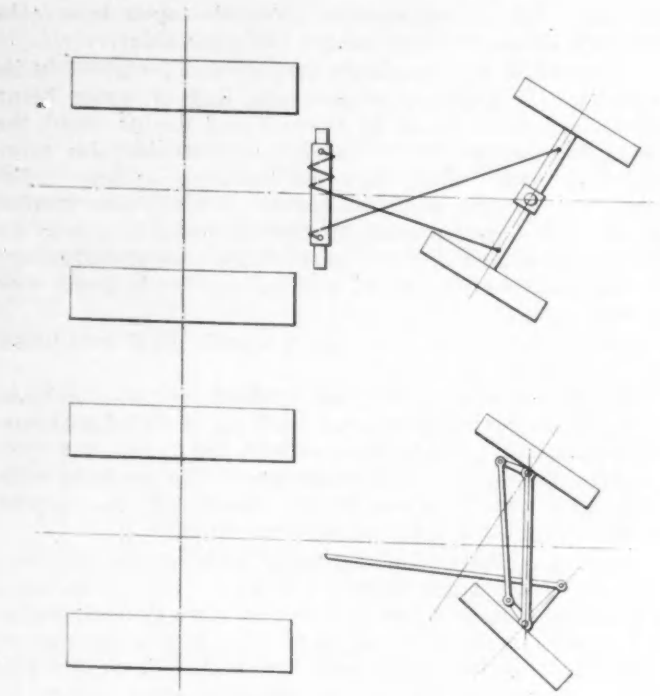


FIG. 11—SINGLE AND DOUBLE PIVOT STEERING TYPES

It is noticeable that there seems to be a tendency in tractors now coming into use to adopt smaller diameter wheels (4 ft.), probably with a view to reduce weight.

The track-laying arrangement, while entirely suitable for special conditions on the land, cannot be considered as an advisable type for regular road work, and is therefore not discussed for the dual purpose called for.

In order to stand up to the road work the wheels of the tractor must be specially strong, though this naturally tends to increase of weight. It is true that, to save in the total weight of the tractor, light wheels might be adopted for work on the land, so designed as to be readily replaced by specially strong and heavy ones when the tractor is required to run on the road. In actual practice, however, the inconvenience and time taken in changing such wheels, together with their considerable extra first cost, would probably limit, if not ultimately eliminate, any advantage there would be in this proposition.

All axles for road locomotion must be mounted on springs, and this can be readily done in the type of tractor adumbrated.

A road engine, besides having all its weight sprung and the wheels of extra strong design, must in itself be so designed as to properly take care of the vibration set up by such duties.

Land Grips.—As has been indicated, the projections attached to the rim of the drive wheels to obtain sufficient hold when plowing, are an important feature, and their design to obtain efficient working is one of no inconsiderable difficulty; the paths traced by three different forms are shown in Fig. 6. The spuds must be of such size and form as to obtain effective hold on the land, and yet not set up too great an increase in rolling resistance by their shape; they should be self-cleaning, and so formed and fitted that, should the differential come into operation and only one wheel revolve, no such side force is set up as may cause the tractor to slip sideways at right angles to its path.

Generally the older forms of tractors, although they gave good service, do not appear to have received sufficient care in their design regarding the points discussed. They frequently lacked the finished appearance of a complete design, owing to the apparently haphazard arrangement of the constituent parts, such as engine and gears, on a rolled section frame.

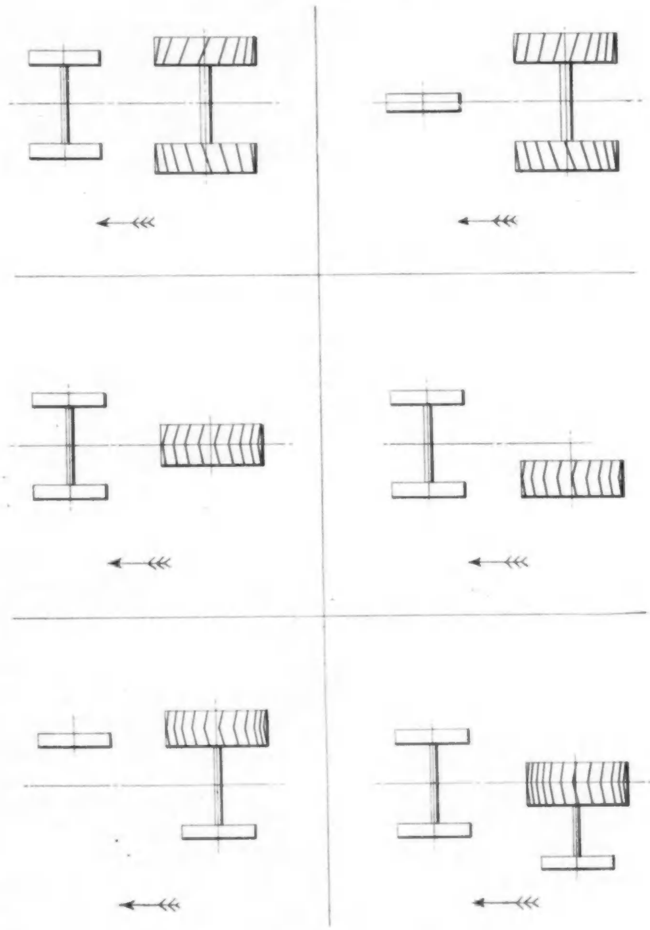


FIG. 12—TRACTOR WHEEL ARRANGEMENTS

Progress in this direction has undoubtedly taken place, as is shown by the light type of tractor now coming on the market, in which a separate frame is obviated, and it is obvious that the design was completed at one time by an engineer with an eye to appearance of the whole.

New York Marine Meeting

On the evening of January 25 a Marine Meeting of the Society was held in New York at the Automobile Club of America. Four addresses were made followed by four motion pictures showing the production of submarine chasers, and illustrating torpedo boats, aircraft, and the heavy duty Liberty motor trucks as now adopted by the War Department.

The professional session was preceded by a dinner at which there were 162 members and guests in attendance. A list of their names appears on page 169. In addition, 175 enlisted men of the U. S. Navy attended the meeting in a body. Following the meeting a buffet supper was served.

Standardization of Submarine Chasers

Standardization, as applied in the marine field, was the keynote of the meeting. The first speaker, Erwin Chase, took as his subject the standardization of motorboat construction, referring particularly to the standardization that was pursued in connection with the construction of the 550 submarine chasers for the British Government, the design of which was in his hands. Until recently there were no large orders for motorboats that would enable manufacturers to really standardize, and they were obliged to meet the individual requirements of purchasers. As it was necessary to fabricate the submarine chasers in this country and assemble them in Canada, standardization of both boats and fittings was found to greatly facilitate the work. They also found on the other side that it was a great advantage to have all these boats exactly alike so that whenever necessary to manufacture new parts in order to make any alterations they would be sure to fit all of the boats. In wooden construction of course it is impossible to build two boats exactly alike and the only difficult part of the standardization problem of the submarine chasers was to have reasonable tolerances at the vital points where various fittings would have to be applied.

Mr. Chase concluded his remarks by stating that he favored more standardization. The designer heretofore has had to make up all his own specifications as there are no standard specifications for most of the materials that are used in motorboat construction and no individual can devote the proper amount of time to getting up elaborate specifications for each detail on a boat. The result is that there is much delay and confusion without standard specifications for the various parts. Mr. Chase referred to the work already done by the Standards Committee and said that the work which it is engaged in now, namely, the standardization of the coupling on the propeller shaft, and work along similar lines, will be a great help to the boat builders.

Work of Marine Division

W. S. Howard next told about the work of the Marine Division during the past year. Concerning the early work of the Marine Division he made the following remarks: "We went over the S. A. E. standards and adopted such things as had already been standardized that were acceptable and applicable to marine work, such as metals, bronzes, rod ends, and some thirty-odd standards that had been in use in the S. A. E. At this time we laid out plans for battery work, couplings, shafts and propeller mouths. While there had been a great deal of work planned ahead, the real work undertaken started with the power from the engine and went right through with the shaft to the nut on the aft-end of the propeller. We did not make any attempt to take care of the bearings or stern tubes at that time. This work resulted in some seven or eight tables and several drawings.

"In order to standardize these things, it was necessary to call in the reverse-gear and the engine people, and agree on some manner in which the latter could have standard couplings on the aft-end of their engine shafts, and allow the reverse-gear manufacturers to make some form of coupling that would match this up.

"As we proceeded with this work, we got uniform sizes, uniform bolt circles and number of bolts, and placed limits on them, and also code words and numbers, so that these could be ordered by number, and the numbers mean something. The first number refers to the diameter of the flange. We had the flanges run in whole numbers, such as four, five, six, seven, eight, nine and ten inches.

"After the engine people and the reverse gear people were willing to consider these as accepted practice, we took up the aft-end of the reverse gear and arranged for a steel coupling to be mounted with a standard taper. These all have given lengths, given keyways, given bolt circles and given pilots. The pilot is always on the driving end. The part that matches this is similar, except that it has an anchorage for the bolthead, and the tapers are held in place with washers and nuts. We made the clearance so that we had room for a socket wrench. After designing this part we realized that there were a great many cases where the small boatman could not go to the expense or he might not have the necessary equipment to fit a taper end. A good many small boat shops prefer to order their shafts slightly longer than they need and then cut them off and put them in straight in the coupling. Wishing to make this standard material as acceptable as possible to all of the trade, we made a substitute coupling of cast iron, having the same flange sizes, bolt circles and clearances, but the shaft sizes are smaller, which automatically takes care of the transmitted horsepower limits due to a cast iron coupling. The substitute coupling is a straight clamp coupling. It is cast solid, bored and reamed and then split into two halves held together on the smaller sizes with two bolts, and on the larger ones with four. These bolts are put in in opposite directions, so that the nuts will counterbalance. The heads are anchored, and the bolts cut slightly into the shaft so that withdrawing is taken care of and this design has the further advantage that it will take care of slight inequalities which always exists in rolled stock.

"Going a little further, extension shafts have a clamp coupling, and after that we have the standard propeller mounts. Through the assistance of Commander Fisher I was brought in touch with the Chief of the Drafting Bureau of the Bureau of Steam Engineering, and I believe we have settled all differences now as to such things as keyways, length of hubs, and separate nuts. In a short time, we intend to take up batteries and standard arms, so that engines within a given horsepower will have a standard bed, and a boatman will know how to provide for the engine whether he knows what engine he is going to get or not."

The third paper was read by Captain A. P. Lundin

covering the subject of the fitting of motorboats to transports. Captain Lundin's paper is printed on page 170.

Vice-president H. R. Sutphen, speaking as chairman of the Marine Division of the Standards Committee, delivered the last paper of the evening on the subject of standardization of marine craft. Following are extracts from Mr. Sutphen's remarks:

Standardization in the Marine Field

"The object of the Standards Committee has been not to standardize designs but to harmonize designs already made. I want to make that very clear, because some have objected to standardization—when the individual thoughts and efforts could perhaps be dwarfed. It is the Society's idea to harmonize what already exists in practical standardization, which carries great weight with the public, because if there is nothing else that this war has taught the world, it has taught it standardization of machinery. Never before has the opportunity been afforded to carry standardization to the limits that we can do today, and particularly is this so in the marine trade, because heretofore boats were built and not manufactured. Every manufacturer, builder and designer has wanted to embody his individual ideas, and that is perfectly proper if we are to be satisfied, as we have been in the past, to do a small business. The first opportunity we had of duplicating in quantity was in the 550 submarine chasers built for the British Admiralty.

"Standardization has enabled us to develop the man power which is so vital to our needs today. These submarine chasers were fabricated a thousand miles from where they were assembled. They were assembled by workmen of whom not 5 per cent could speak a word of English, and not more than 2 per cent had ever been near a boat yard before. The secret of that was simple. The design was so standardized, the parts were so manufactured in fabrication that the assembly became entirely mechanical, and we could teach it to any man willing to learn.

"You are all interested in knowing what this has led to in boat work, and I think the work that my firm is engaged in, as an agent for the United States Government, of building 150 five-thousand-ton steel cargo ships by standardized methods will appeal to all.

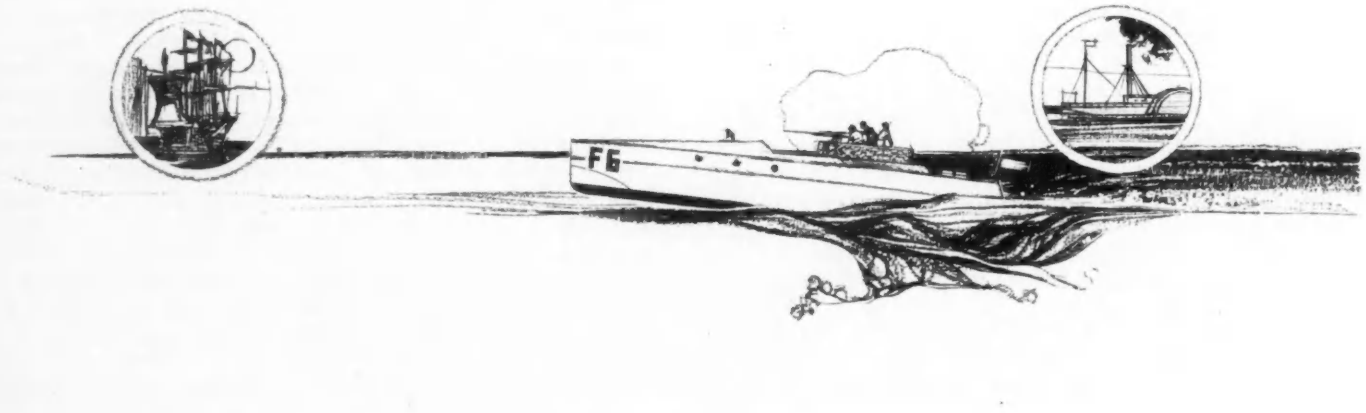
"You will remember the discussion last April of how to win the war. A thousand wooden boats was a dream of some man, and he wasn't far wrong in the number, but, having had experience in handling wood in the small boats, we personally knew the limitations of standardizing in wood, as wood will not "stay put" like steel after finishing a detail of fabrication. It will do much better in small sizes than in the large timbers used in ship construction. We suggested to the Government that instead of wooden ships they build steel ships. We evolved a plan for a ship using structural steel which, after careful investigation by the classification societies, Lloyds and American Bureau, was passed by them as one equal in every detail of strength and design and construction to the best ships heretofore built with ship steel.

"We had to obtain a big organization at once, and we turned to the trades that we felt would be idle on account of our entrance into the war—the building trades and the bridge companies. We have laid to date four keels of the 5000-ton ships, and would have laid more if the railroads had not interfered with delivery of our fabricated material. Forty-six shops all over the country are fabricating today the material to go into those ships, and every man in those shops realizes that he is doing his bit to win the war. Over 90 per cent of the material will be fabricated in these structural shops. The machinery has been thoroughly standardized and will come from the largest manufacturers of ship machinery. We there followed the line of least resistance in manufacturing, and, instead of the slow reciprocating engine, turned to the turbine. When the plant is going at Newark Bay at maximum capacity, our schedules call for one complete ship every two working days.

"The man power is the vital thing. We have established schools to instruct these iron workers that have been accustomed to go to the heights of sky-scrapers and do classes of work there that the shipwright has never done. We will teach each man just one detail in which he will become proficient in a remarkably short time, as has already been proved.

"We are convinced that this work can be done as planned and only these methods can produce the bridge of ships which must connect Europe with America in the shortest possible time. The Government now recognizes this, and two other large fabricating yards have been established and will soon be under full headway.

"Is is very fitting, I think, that our Society has entered into the work of standardization at this time. The great quantity of production offers great possibilities, and I want, as I know my associates do, to have every one feel that any suggestions that can be made from time to time on subjects that the Marine Division should take up will be most welcome. We will not go along at a too rapid rate. We want to have these things talked over, back and forth."



ATTENDANCE AT THE MARINE MEETING

MEMBERS

ALLERTON, REUBEN, Allerton Engineering Corp., *New York*.
AMORY, C. G., Gas Engine & Power Co., *New York*.
AMORY, JOHN J., Gas Engine & Power Co., *New York*.
BARTER, P. L., McCord Mfg. Co., *Detroit*.
BENNETT, H. W., Sumter Electrical Co., *Chicago*.
BERGMANN, A. C., Standard Parts Co., *New York*.
BISSELL, C. R., Markt & Hammacher Co., *New York*.
CHANDLER, M. E., Stromberg Motor Devices Co., *Chicago*.
CHATAIN, HENRI G., General Electric Co., *Erie, Pa.*
CLARKSON, COKER F., Society of Automotive Engineers, *New York*.
COGGESHALL, G. W., Institute of Industrial Research, *Washington*.
CRIDER, J. E., The Water Craft Co., *New York*.
CUMNER, A. B., Autocar Co., *Washington*.
DABNEY, HOWARD D., Society of Automotive Engineers, *New York*.
DARRACH, BRADFORD, JR., Laminated Shim Co., New York.
DAVIDS, WM. C., Rutherford, N. J.
DUESENBERG, F. S., Duesenberg Motors Corp., Elizabeth, N. J.
FROMME, H. E., Gas Engine & Power Co., *New York*.
GIFFORD, F., Bijur Motor Lighting Co., *Hoboken, N. J.*
GRIFFIN, G. BREWER, Westinghouse Electric & Mfg. Co., *East Pittsburgh, Pa.*
GURNEY, E. R., Knox Motors Co., *Springfield, Mass.*
HANKS, M. W., Society of Automotive Engineers, *New York*.
HELDT, P. M., *The Automobile*, New York.
HERRESHOFF, A. G., International Motor Co., *New York*.
HODGES, E. R., *Irvington, N. J.*
HOWARD, W. S., F. K. Lord, *New York*.
JARDINE, ROBERT, Railway Exchange Bldg., *Chicago*.
JENNINGS, W. F., Bound Brook Oil-less Bearing Co., *Bound Brook, N. J.*
KEBLER, LEONARD, Ward Leonard Electric Co., *Mt. Vernon, N. Y.*
LACY, V. E., James Cunningham & Co., *Rochester, N. Y.*
LEE, T. L., North East Electric Co., *Rochester, N. Y.*
LIBBY, A. D. T., Splitdorf Electric Co., *Newark, N. J.*
LLOYD, R. MCA., Mantle & Co., *New York*.
LOO, W. P., Curtiss Engineering Corp., *Garden City, N. Y.*
LUCKE, C. E., DR., Columbia University, *New York*.
MCKEOWN, S. C., Splitdorf Electrical Co., *Newark, N. J.*
MCMINN, S. P., *Motor World, New York*.
MARBURG, LOUIS, Marburg Bros., Inc., *New York*.
MASON, F. L., lieutenant, U. S. Navy Gas Engine School, Columbia Univ., *New York*.
MAYO, V. J., Mayo Engineering Co., *New York*.
MEAD, GEORGE J., Simplex Automobile Co., *New Brunswick, N. J.*
MILLER, C. A., first lieutenant, Quartermaster Corps, National Army, *Washington, D. C.*
MOONEY, W. H., The Dayton Engineering Laboratories Co., *Dayton, Ohio*.
MUDGE, C. A., Electro-Dynamic Co., *Bayonne, N. J.*
NILSON, LARS G., Nilson-Miller Co., *Hoboken, N. J.*
NORTON, WALTER W., Autocar Co., *Ardmore, Pa.*
OCHS, S. O., Pluym-Ochs, Ltd., *New York*.
PERKINS, EDWIN A., *Jamaica, N. Y.*
PHILIPS, EDWIN S., Philips-Brinton Co., *Kennett Square, Pa.*
PHILLIPS, F. F., *Flushing, N. Y.*
PLIMPTON, R. E., Society of Automotive Engineers, *New York*.
POTTER, A. E., lieutenant, U. S. N. R. F., *Brooklyn, N. Y.*
SCHEEL, H. V. R., Brighton Mills, *Passaic, N. J.*
SCOTT, CARL F., Sprague Electric Works, *New York*.
SLAUSON, H. W., *Leslie's Weekly*, New York.
SMALLEY, G. O., Bound Brook Oil-less Bearing Co., *Bound Brook, N. J.*
SMITH, H. A., Bijur Motor Lighting Co., *Hoboken, N. J.*
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TANNER, P. ARTHUR, Sumter Electrical Co., *Chicago*.
THURSTON, E. D., lieutenant, U. S. Navy Gas Engine School, Columbia Univ., *New York*.
VAN BLERCK, JOSEPH, Van Blerck Motor Co., *Monroe, Mich.*
WILLIAMS, LOUIS W., Union Drawn Steel Co., *New York*.
WOLF, AUSTIN M., American Motors Co., *Plainfield, N. J.*
WOODBURY, A. C., Duesenberg Motors Corp., *Elizabeth, N. J.*

GUESTS

ABBOTT, H. H., Regal Gasoline Engine Co., *Coldwater, Mich.*
ALDREDGE, A. F., The *Rudder, New York*.
ALLEN, E. K.
ATHERTON, C. A., ensign, Submarine Base, *New London, Conn.*
BARNARD, J. H., commander, lieutenant, Submarine Base, *New London, Conn.*
BECKWITH, WM. R., Duesenberg Motors Corp., *Elizabeth, N. J.*
BEEKER, SIDNEY K., Standard Oil Engine Co., *Bridgeport, Conn.*
BELDING, L. A., Professor, Stevens Institute of Technology, *Hoboken, N. J.*
*BOLGER, ROBERT S., International Motor Co., *New York*.
BOYD, R. J., Van Blerck Motor Co., *Monroe, Mich.*
BRENZONGER, JULIUS, Maxims Machine Co., *Bridgeport, Conn.*
BREWER, J. W., International Motor Co., *New York*.
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BUCKMASTER, B. S., ensign, U. S. Navy Gas Engine School, Columbia Univ., *New York*.
BYRON, E., Stevens Institute of Technology, *Hoboken, N. J.*
CARR, H. LOVELL, Duesenberg Motors Corp., *Elizabeth, N. J.*
COLE, F. A.
COMSTOCK, D. R., August Mietz Corp., *New York*.
CROUCH, GEORGE F., *Motor Boat, New York*.
CRUM, J. F., U. S. Navy Gas Engine School, Columbia Univ., *New York*.
DALZELL, A. H., Endle Perforating Co., *Rochester, N. Y.*
DAVIS, C. W., The Torrington Co., Standard Plant, *Torrington, Conn.*
DUTCHER, F. H.
DYER, K. W., Frisbie Motor Co., *Middletown, Conn.*
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FARR, J. B.
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GODDARD, F. B., U. S. Navy Gas Engine School, Columbia Univ., *New York*.
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GRUMMAN, L. R.
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HALLIDAY, W. R., Professor, Stevens Institute of Technology, *Hoboken, N. J.*
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HAUCHETTE, A.
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KENT, WINTHROP, ensign, Submarine Base, *New London, Conn.*
KLEMDIENST, R. J., Standard Parts Co., *New York*.
LEA, ROBERT B., The Sperry Gyroscope Co., *Brooklyn, N. Y.*
LOTT, F. H., Professor, Stevens Institute of Technology, *Hoboken, N. J.*
LOVEDAY, G. R., Sumter Electrical Co., *Chicago*.
LOW, E. H.
LOWEREE, H. W.
LUCAND, A., International Motor Co., *New York*.
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MORGAN, WM. FINLAY.
*MURRAY, J. J., Murray-Willat Co., *New York*.
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NUTTING, WM. WASHBURY, *Motor Boat, New York*.
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PATTEN, F. H., Westinghouse Electric & Mfg. Co., *Pittsburgh, Pa.*
PATTERSON, H. W., Gas Engine & Power Co., *New York*.
PELLEGRINI, G.
PICARD, A. C., McCord Mfg. Co., *Detroit*.
REID, J. E., International Motor Co., *New York*.
ROBINSON, L., Standard Varnish Works, *New York*.
ROBINSON, P. H., Regal Gasoline Engine Co., *Coldwater, Mich.*
ROGERS, WM. B., *Motor Boat, New York*.
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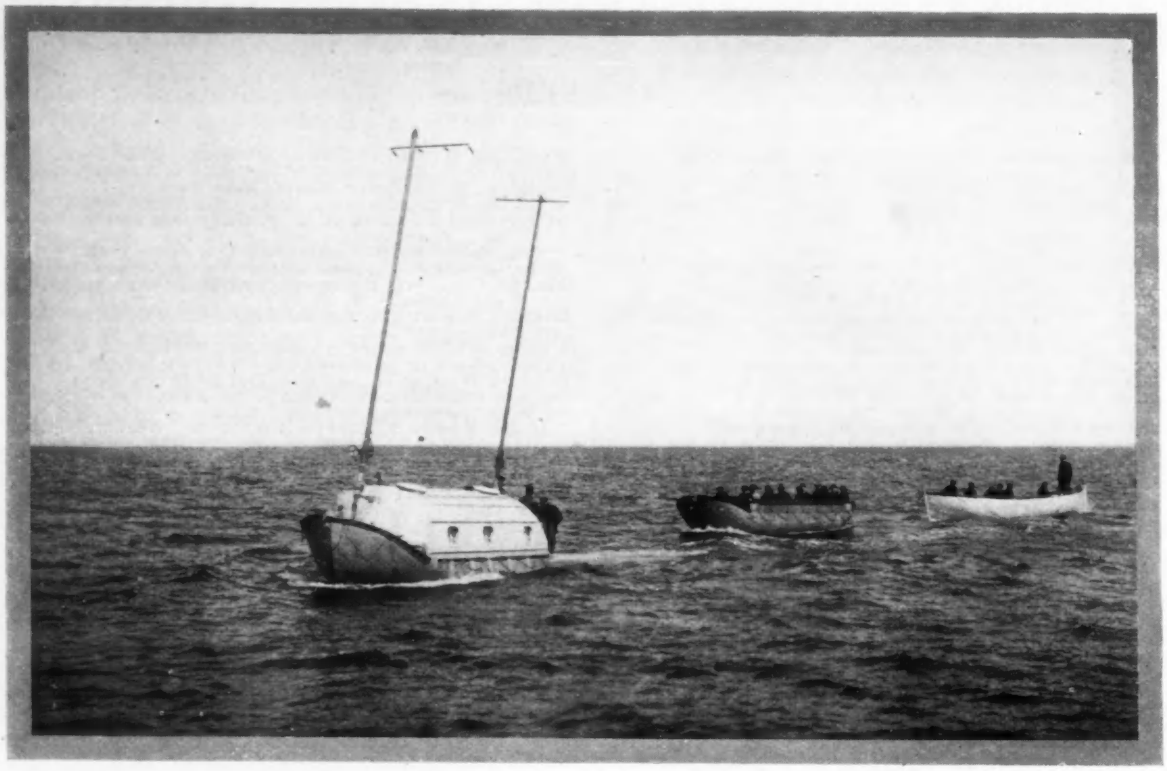
SCRIMGEOUR, B., Gas Engine & Power Co., *New York*.
SEARLE, R. B., ensign, U. S. Navy Gas Engine School, Columbia Univ., *New York*.
SELLING, H. M.
SHELLEY, S. M., Electro-Dynamic Co., *Bayonne, N. J.*
SHIRE, ALBERT, Stevens Institute of Technology, *Hoboken, N. J.*
SLEFFEL, C. C., lieutenant, U. S. Navy Gas Engine School, Columbia Univ., *New York*.
SMITH, A. O., ensign, U. S. Navy Gas Engine School, Columbia Univ., *New York*.
SMITH, J. HENRY, Rich Tool Co., *Chicago*.
SMITH, L. V.
SNELLING, J. H., Marine Mfg. & Supply Co., *New York*.
SNELLING, P. W., Marine Mfg. & Supply Co., *New York*.
STARBUCK, F. I., ensign, U. S. Navy Gas Engine School, Columbia Univ., *New York*.
STEPHENS, W. P., Lloyd's Register of American Yachts, *New York*.
STONE, EDWARD J., Knox Motors Co., *Springfield, Mass.*
STONE, J. P., Lindeteves-Stokvis, *New York*.
STROHM, R. T., *Power, New York*.
STUBNER, W. F., International Motor Co., *New York*.
SWEET, S. H., Standard Oil Engine Co., *Bridgeport, Conn.*
THOMAS, C. W., lieutenant, U. S. Navy Gas Engine School, Columbia Univ., *New York*.
THOMPSON, F. G., Sheffield Farms Co., Inc., *New York*.
TRUDEAU, J. F., Electro-Dynamic Co., *Bayonne, N. J.*
WOOLSEY, FRANK, Woolsey Paint & Color Co., *Jersey City, N. J.*
WORTHLEY, MONTAGUE.
WYGODSKY, LEON, *Baltimore*.
YOUNG, FRANK O., E. J. Willis Co., *New York*.

*Applicants for membership.



Thirty-Foot Motor Lifeboat with 50 Persons Inside House Towing Two Open Boats at Sea

Fitting Motorboats to Transports

By CAPT. A. P. LUNDIN* (*Non-Member*)

MARINE MEETING PAPER *Illustrated with* PHOTOGRAPHS

THEY are calling the new industries "war babies" nowadays, so in a measure we can regard all our new ships as Uncle Sam's war babies. But to take care of babies properly, doctors and nurses are needed, else there may be trouble. So it will be well to bear in mind the proper manning of these ships, with navigators, engineers and seamen.

Many landlubbers have a theory that "sailors," from captains to deckhands, can be turned out as fast as hot cakes; or, in other words, that men to run ships can be trained like chauffeurs to run automobiles.

Any man who has had experience in navigating knows that it takes more than theoretical knowledge. Besides the actual science of navigation we must also consider the importance of good judgment when approaching land, particularly in thick or rough weather. Of course, soundings are made with the line, but a good sailor must rely a good deal on his eyes, and even on his nose, and that so-called sea sense of an old tar is not learned in a school. It can be acquired only by years of actual experience at sea.

What is true of the chart room and bridge also applies to the engine room, where it is sometimes a case of keeping the engine running even with a leak in the steam pipe and hot bearings in the engine.

We may build a merchant marine in short order, but we cannot give officers and engineers the physical and mental training to meet all emergencies with the same record speed, so it is more important than ever to take due precautions as to the floatage equipment—the lifeboats and rafts—so that in case of accident as many as possible of our valuable trained officers, seamen, and our soldiers on the transports, can be saved to serve their country.

When it comes to saving lives, the best equipment is none too good, and results from observing the policy of "getting the cheapest" are often disastrous. The majority of builders follow the old principle of turning out the cheapest article possible that will pass the law. This generally leads to cutting prices and to "skinning" on the work.

A few builders have tried to turn out the best article possible, but they are handicapped by the more cheaply constructed articles, for it is difficult to convince shipyards and operators of the advantage to be gained by paying a little more and getting better equipment.

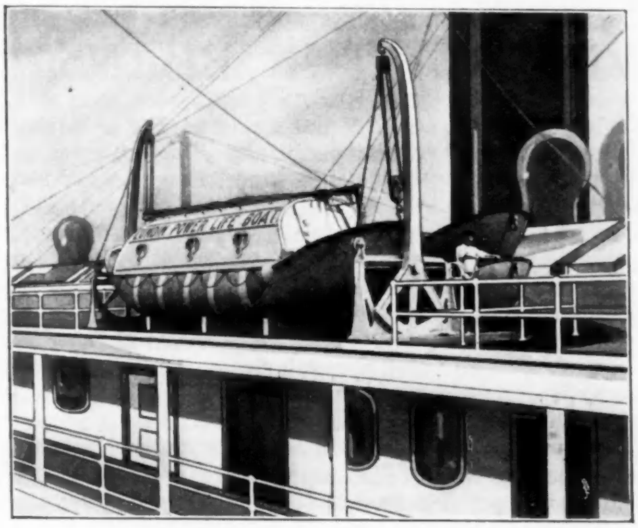
The safety of all on board does not depend on the lifeboats alone, but also on the chocking and stowing, the davits, the releasing gears—in fact, on the merits and efficiency of even the smallest detail of the equipment—and last, but not least, on the drills, which should be carried on frequently, and under conditions as nearly as possible like those that obtain in case of accidents at sea, so that sailors and soldiers, as well as passengers, may grow accustomed to the handling of the lifesaving apparatus under strain of excitement.

*President, Welin Marine Equipment Co.

Mechanical Davits

I consider mechanical davits a necessity; this was recognized in the rulings made some years ago by the International Conference on Safety of Life at Sea. And it must be a mechanical davit that permits the swinging out of loaded boats, keeps them under control at all times during launching, and, above all, with sufficient power so that the boats on the high side of the ship, in case of a list, will not be useless. Moreover, it must be simple to operate, and have no intricate parts that can be put out of business by weather conditions at sea.

The chocking is also important, and even seconds count when it comes to releasing the boats in time of danger. Before the war, when passenger traffic was heavy, our ocean liners had to carry "boats for all" and to save deck space the so-called pontoon boats, built of flimsy material, were stowed under the regular lifeboats. But this type of boat is not strong enough to support the open lifeboats without extra heavy chocks, made up with the help of beams, stanchions and bolts. Of course, it takes a long time to release such boats, and even at best they are not reliable for lifesaving.

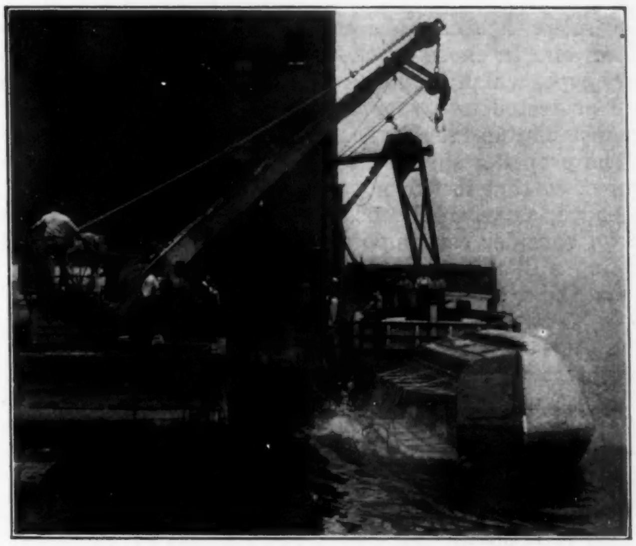

30-Ft. Motor Lifeboat Being Stowed Outside Nest of Two Open Boats

I much prefer a light raft to these folding contraptions, because the former can be thrown overboard easily, if it comes to the worst, and will serve as an emergency support for those who are swimming or floating about with only a life preserver to save them from drowning.

Motor Lifeboats

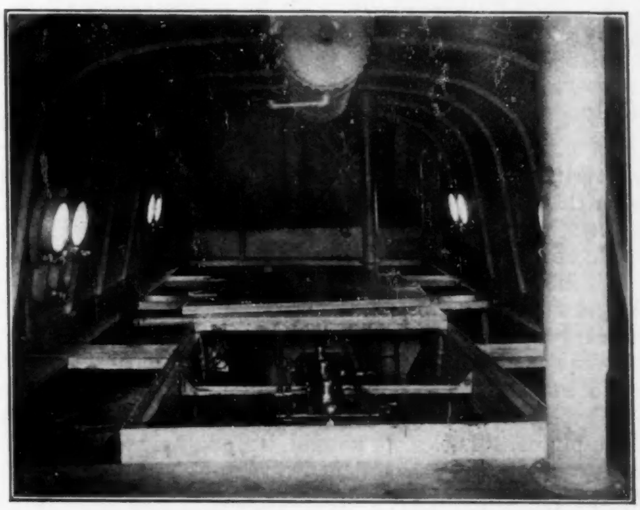
Under present conditions, I consider the motor lifeboat the most important of all modern improvements in the field of lifesaving equipment. A couple of years ago a new law was passed that all passenger ships under the American flag should be equipped with at least one motor lifeboat, but in my estimation it is just as important that every cargo ship should be equipped with one likewise.

Even today there is a difference of opinion among captains, navigators, and seamen generally, as to the value of a motor lifeboat. The reason for this may be sought in human conservativeness when it comes to new things, and in this respect the sailor is apt to be as cautious as the landsman. However, in a heavy sea, a properly constructed motor lifeboat is as far ahead of a regular lifeboat propelled by oars as a big automobile truck is ahead of a pushcart on land.


Testing 30-Ft. Motor Lifeboat. Righting Itself Within 20 Sec. from Time It Was Bottom Up, After Being Capsized

The ideal motor lifeboat should be so constructed that it can be launched under davits and also without davits; in case the ship sinks quickly, the crew can get into the cabin of the boat, close the doors, and when the ship goes down the boat will take care of itself. It should be built of steel, with large, thick balsa wood fenders so that it cannot be crushed in. The beam should be at least one-third of the actual length, and there should be a great deal of excess buoyancy, so that it cannot be swamped or capsized. Even if it should turn over—which might occur if it were hit by a spar or smokestack with tremendous force—it could soon right itself.

In order to build an efficient boat it will necessarily be large and heavy, and it would be almost impossible to handle it with oars in a heavy seaway. Besides, if such a boat has power equipment, it will become a mother ship to the other lifeboats, which can be towed and kept together, instead of drifting over the ocean and getting lost. The motor lifeboat can carry more food and provisions than the others, and can thus help them out; when the weather is stormy and cold, the people in a housed motorboat will be protected against the sufferings due to exposure to wind and sea.


Interior of 30-Ft. Motor Lifeboat, Equipped with 20-24-Hp., 4-Cylinder, Standard Engine. Average Speed 7 m.p.h.

A motor lifeboat does not have to be a boat of high speed, and in choosing the engine I advocate the heavy-duty type, which is more reliable. The engine should be well protected in a separate steel trunk, so as to insure against engine trouble from the effects of salt water.

The propeller should also be protected, preferably in a tunnel, so that it will not easily get bent or twisted out of shape, as when the boat is being launched or floated off. I consider this important, even to the extent of sacrificing a little speed.

For the average freight ship I recommend a boat from 26 to 33 ft. in length; in most cases this boat would take care of the entire crew. A 28-ft. boat for the smaller freighters would have a capacity of from forty to fifty persons, and in emergencies could carry double the number.

Its fuel capacity is about 150 gal., which, with a 24-hp., heavy-duty engine, would carry it about 300 miles at a speed of from six to seven miles per hour.

The total weight of such a boat would be about 9000 lb.; and, considering that we have davited without trouble boats of from 40 to 50 tons, this could be readily taken care of as far as launching is concerned.

Of course, such boats are somewhat expensive compared to the ordinary lifeboat, but even if they cost a few thousand dollars what does it matter if by their use a few more lives can be saved? And actual lifesaving should be the prime consideration to those entrusted with the equipment of our ships.

Insurance companies and underwriters keep an accurate record of improvements in fire-extinguishing apparatus, pumps, boilers, and engines, just as architects and fire underwriters for buildings have a most explicit rating on fire-protection and elevator systems, yet the former are concerned only with the cargo of ships and the saving of property, whereas little attention is paid to the kind or quality of lifesaving equipment carried on the ships to safeguard the crews. Considering the fact that our Government is now taking the lead in underwriting the lives on ships that cross the "war zones," I think it would be well for all concerned with the matter to do their bit toward avoiding loss of life.

CONTRACTS FOR GROWING CASTOR BEANS

IN view of the heavy demand for castor oil as a lubricant for aeronautical engines, it is believed that the following excerpts will be of interest to some members of the Society. They are taken from a recent announcement of the Bureau of Plant Industry of the U. S. Department of Agriculture.

The Chief Signal Officer of the Army, Washington, D. C., has contracted for a large acreage of castor beans throughout the Southern States. The entire acreage allotted has been contracted for. No contract was written for less than one hundred acres, since small contracts would involve too much Government supervision.

Small planters have been encouraged to contract with the nearest large contractor having the necessary authority to make sub-contracts. Sub-contractors can obtain seed direct from the nearest large contractor whose name will be furnished upon application to the Chief Signal Officer, Equipment Division, Castor Oil Section, 119 D Street, Northeast, Washington, D. C.

If it is desired to grow castor beans for the open market, for which it is believed there will be a demand, seed for planting may be obtained at a reasonable price from the Baker Castor Oil Company, 120 Broadway, New York City, of whom the Government has purchased its seed requirement.

Castor Bean Culture

For the commercial production of castor beans, the warm climate and longer growing season of the more southern states is necessary. If planted much further north than St. Louis, Mo., or Washington, D. C., the crop is very likely to be caught by frost. In general, any fertile soil which produces good crops of cotton or corn is suitable for castor beans, but a very fertile soil favors the growth of the plant at the expense of seed production and early maturity. The land is prepared in much the same manner as for cotton or corn: that is, plowed, disked, and harrowed level before planting, which may be done by hand or with a corn planter with specially prepared plates. The seed should be planted early in the spring as soon as the soil is warm, but still moderately moist. The time of planting varies according to locality, but in general corresponds to that of cotton. A good time for planting in central Oklahoma would be about the first of May, and correspondingly earlier in localities to the south. In central peninsular Florida, conditions will probably be suitable any time after the middle of March.

In planting for commercial purposes a distinction should be made between the ornamental and the oil-producing varieties. The seeds of the latter are small to medium in size, usually about 2/5 to 3/5 in. long and 1/4 to 2/5 in. broad, oval in shape, smooth and shining, and of a gray ground color, irregularly marked with brown. The most desirable beans run from about 69,000 to 115,000 per bushel of 46 pounds.

The number of acres a bushel of beans will plant depends upon the size of the bean and the method of planting. The larger size beans will plant from 6 to 20 acres per bushel, depending upon local conditions.

It is claimed that a man giving his whole attention to the crop can manage from 5 to 10 acres during harvest, and that two men together can handle 10 to 15 acres and attend to other necessary work in connection with drying and cleaning the beans.

The yield will depend much upon cultural conditions, upon the season, and the care exercised in harvesting and thrashing the seeds. Yields of 30 to 40 bushels per acre have been reported from Florida, South Carolina, Georgia, Texas and California. In the Middle West yields of 15 to 25 bushels per acre have been reported under favorable conditions. Much smaller yields will, of course, result if conditions are unfavorable.

High Prices For Castor Oil During War

Until recently the farm price for castor beans has been not far from $1 per bushel. The increased demand for castor oil due to war conditions has caused the price of the beans to advance rapidly, and it is probable that high prices for castor beans will prevail until the end of the war. The normal market requirement in the United States for castor beans is about 1,000,000 bushels annually, but until present conditions change materially, a larger quantity will be needed.

Owing to the heavy outlay required for the necessary machinery and the high cost of manufacture on a small scale, it has not been found profitable for the growers of castor beans to undertake the extraction of the oil.

NAVY AIR SERVICE DEVELOPMENT

IN his annual report for 1917 the Secretary of the Navy makes the following observations concerning the development of the Navy air service: "In my report a year ago I was compelled to state that 'the development of air craft in the Navy has not progressed as rapidly as its usefulness demands.' During the past year there has been an enormous expansion and development of the naval air service which may be said to date from the passage of the naval act of August 29, 1916. The appropriations for aviation for the Navy since July 1, 1916, have been $67,-633,000. Up to this time naval aviation had been almost entirely in the experimental and development stage, and there were comparatively few officers who were aviators.

* * * *

"To build up a flying personnel was necessarily a primary requirement and for this purpose the flying school at Pensacola was enlarged and reorganized, and seaplanes constructed in quantity of a type suitable for instruction purposes, incorporating all safety features known to the art at that time. The design of this school seaplane was outlined by the department and arrangements made with a contractor for its supply. Other builders were encouraged to develop improvements, and the department now is able to purchase satisfactory school seaplanes from at least four builders.

"The supply of school seaplanes is now considered adequate to meet the needs of all of the training stations.

"To broaden the training and to bring in new ideas, men have been sent to France, England, and Canada for flying instruction.

"As the training of men progressed, every effort was made to develop seaplanes of greater power and endurance for service use. This development has been badly handicapped by lack of a suitable high powered American engine, but eventually one builder succeeded in developing a 200-horsepower tractor seaplane largely under the encouragement and assistance of the department. Seaplanes of this type were then supplied in quantity to the coastal air stations which were established after the declaration of war and are available for operation from these air stations.

* * * *

"The so-called Liberty engine developed by the Aircraft Board gives every promise of providing an adequate power plant for service type aircraft. The engine has been installed in a seaplane and in a flying boat and the preliminary tests have been quite satisfactory.

* * * *

Flying Boat a Success

"Eliminating types which had been tried and found unsuitable, the department fixed upon two sizes of flying boats for foreign duty, which had been perfected in the United States in anticipation of a high-powered engine becoming available. For sea work, foreign opinion at the present time, as well as our own, strongly favors the flying boat. This type is an American conception and it is a satisfaction to be able to state that here, at least, American designs have been well to the front and that it is not necessary to copy foreign patterns in order to insure our flyers being supplied with the best. It may be stated with confidence that at the present moment we have an American flying boat actually flying with an American engine which is unexcelled by any foreign craft of the type.

* * * *

"The ship launching-catapult for seaplanes has been successfully demonstrated.

Dirigibles Designed and in Use

"Observing the growth of the submarine menace it became clear that every weapon should be developed for and against it. Airships or dirigibles of modern European type have never been constructed in the United States, but from such information as was available a design of a coast-patrol type was prepared in the department and a number of units have been successfully completed by several companies. A training school for dirigible pilots was established in Ohio, and a number of officers have become skillful operators. Coastal dirigible stations are being established from Massachusetts to Panama.

* * * *

Construction Program

"With the entry of the United States into the war the demand for aircraft from the War and Navy Departments necessitated an enormous expansion of production facility. As a part of this expansion the department undertook to build and equip a naval aircraft factory at the Philadelphia Navy Yard. Within 90 days from the date that the land was assigned the factory was erected and the first flying boat keel laid.

"The Aircraft Production Board, now the Aircraft Board, has assisted the department with its larger contracts and arranged to make available for the Navy industrial resources to meet the next year's program. Five private plants are devoted entirely to Navy work, and a large proportion of two other plants are assigned to the Navy.

* * * *

Cooperation in Aircraft Development

"In the course of the year the department in its aeronautical work has enjoyed the full benefits of the assistance of other governmental agencies. There has been the closest cooperation with the War Department, with very practical results in elimination of conflict in obtaining material and in standardizing specifications. The Bureau of Standards, Forest Service, the Naval Consulting Board, and the Advisory Committee for Aeronautics, and various committees of the National Research Council have been called upon in connection with several perplexing problems which presented themselves.

"The Aircraft Board recently legalized and taking its membership, one-third from the Army, one-third from the Navy, and one-third from civil life, is continuing the excellent work done by the Aircraft Production Board which developed the Liberty engine. The Army and Navy members consist of the officers who have charge of aeronautical matters in their respective departments, and the board operates under the direction and control of the Secretary of War and of the Secretary of the Navy. Thus in all matters affecting the present gigantic problem of aircraft production and in dealing with the aircraft industry generally the two services act as a unit. In addition, there is a joint Army and Navy technical board which passes upon all new designs for either service.

Death of Sir John W. W. Barry

FATHER OF STANDARDIZATION

ON Jan. 22, Sir John Wolfe Wolfe-Barry, K.C.B., LL.D., F.R.S., widely known engineer, died in London. Although he had gained an international reputation as consulting engineer to many railways and public works corporations, as Royal Commissioner on several important projects, and as a leader in engineering society and education circles, the chief interest in his career to the S. A. E. is found, perhaps, in the fact that his influence was largely, if not principally, responsible for the inception of mechanical standardization as it is known today.

The outcome of his proposals is well described in the following statement* by the secretary of the Engineering Standards Committee of the British Association.

"The movement, as represented by the Engineering Standards Committee, the greatest voluntary effort of its kind, in which public spirit has been so lavishly shown, was founded in 1901, through the initiative of Sir John W. W. Barry, K.C.B. In January, 1901, he laid the matter as affecting the engineering trades of the country before the Council of the Institution of Civil Engineers, with the result that a committee was appointed to consider the question of standardizing various kinds of iron and steel sections. The committee reported favorably on the project, and the Council of the Institution of Civil Engineers adopted the report, and the cooperation of the five leading engineering institutions of the kingdom:

The Institution of Civil Engineers,
The Institution of Mechanical Engineers,
The Institution of Naval Architects,
The Iron and Steel Institute,
The Institution of Electrical Engineers,

was subsequently secured. The original reference to the committee was enlarged by resolution of all the councils of the supporting institutions, and full power was conferred on the committee as to publication and the best manner of giving effect to their findings.

"Thus from a single committee, consisting originally of seven members, appointed to discuss the advisability of standardizing rolled sections and rails, has grown the present far-reaching organization, with its 64 committees and sub-committees, as well as numerous panels, including, in all, well over 500 members freely giving their time and experience, often at great personal inconvenience, and dealing with subjects embracing practically the whole of engineering practice."

Sir John W. W. Barry's own ideas on standardization and his own account of his connection with the subject were presented in a lecture† entitled Standardization and Its Relation to the Trade of the Country, delivered at Glasgow before the Institution of Engineers and Shipbuilders, some years ago. The lecture has been aptly referred to as in many respects the Magna Charta of standardization in mechanical engineering design and construction. The passages below taken from the lecture are of live interest today:

"Up to recent years there has been comparatively little effort toward the realization of engineering standards. Since Sir Joseph Whitworth, in 1841, made a notable step with his standards of screw threads, very little was done in the same direction for sixty years, although the benefits which he conferred are still conspicuous and unquestionable. The want of some systematic dealing with the whole subject of engineering manufactures was borne in on myself, as it must have been on very many, when in the early stages of my professional career I was personally engaged in designing and specifying various kinds of structures and materials—and I have felt the necessity all my life of some systematic treatment of these subjects.

"That some effort to systematize design and production of component parts should be made had been, as I said, long in my mind but it received a great stimulus in 1897 from some remarks of the late Lord Salisbury to an important scientific deputation, which resulted shortly afterward in the establishment of the National Physical Laboratory.

"In January, 1901, I accordingly, but with some trepidation as to the result, moved in the Council of the Institution of Civil Engineers a resolution that definite action should be taken by them to draft standard forms for iron and steel sections. Some difference of opinion was evident on the subject in certain important quarters, the fear being that it would be a step toward the discouragement of individuality of design, and that there might be a tendency toward a stereotyping of forms which ought to be varied to meet requirements as they might arise. On the other hand, it was pointed out: first, that the system proposed was not of a nature which could affect the design of the assembled parts in a bridge, roof or ship, in which the individual mind would have as full play as ever; and secondly, that the idea proposed was not the adoption of standard forms once for all, but that a cardinal point of the idea was that some commitee of qualified persons should be instituted, who, after dealing with the subject at one particular epoch, should have a continued existence in order to discuss, and, if approved, adopt as additional standards, forms which from time to time were shown to be proper and desirable.

"It also became apparent that the engineering industry of this country would profit considerably in many directions if standardization on a judicious scale were initiated in the nature of the materials as well as in the form of manufactured articles. The many specifications differing often in unimportant and trivial details were in many cases involving much increased cost without corresponding advantage to the purchaser in the article produced."

Sir John Wolfe Wolfe-Barry was born Dec. 7, 1836, the youngest son of Sir Charles Barry, R.A. He was educated at Trinity College, Glenalmond and King's College, London. In 1874 he married Rosalind Grace Rowsell. He had four sons and three daughters. He was a member of the Senate of London University, Governor of the Imperial College of Science and Technology, Past-president of the Inst. of Civil Engineers, a member of the Inst. of Mechanical Engineers and of other societies and author principally of books pertaining to railway subjects.

*Paper read before Section G of the British Association and reported in *Engineering*, Sept. 8, 1916.

†The lecture appears in more complete form in the S. A. E. Bulletin, Vol. III, No. 1.

PROPOSED SYMBOLS FOR ELECTRICAL CIRCUITS

ABOUT a year ago the Standards Committee of the American Institute of Electrical Engineers appointed a Sub-committee on Symbols. This was at the request of the British Engineering Standards Committee which was then actively considering the question of standardization of symbols.

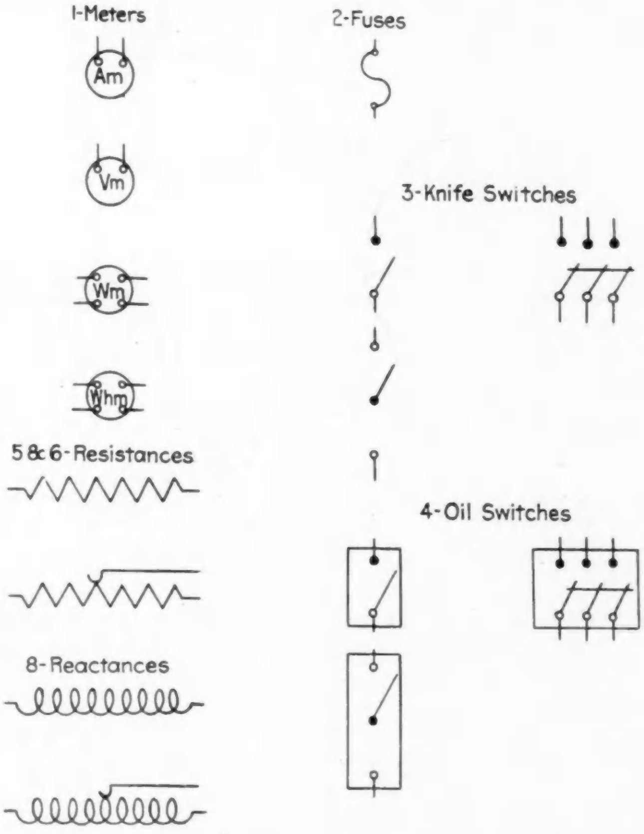
In a memorandum the sub-committee has stated its opinion as follows:

1—A symbol should be as simple as possible.

2—It should conventionally convey, insofar as possible, what it is intended to represent without making a picture.

3—A more general use of letters and abbreviations in connection with symbols, as shown in the accompanying list, is advisable.

The committee recommends that the following list be adopted by the Institute for use in its Transactions and that from time to time this list be increased until the field is well covered. In general the proposals follow the British and Italian symbols.



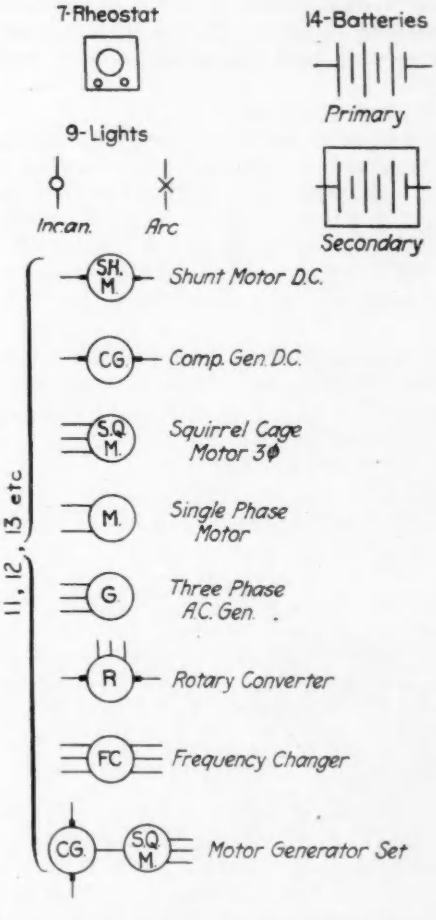
1. *Meters*—Recommended that symbols for all classes and types of meters be represented by a circle with the necessary letters within the circle to indicate its use. If used in connection with a diagram, that dots be added for connections.

2. *Fuses*—There are two types of symbols generally shown for fuses; one of them is the letter "S" connecting two dots. This evidently was originally supposed to be a picture of the lead wire fuse twisted around two binding posts. The other symbol in general use is the picture of the cartridge fuse. The committee recommends the adoption of the first type. It is easily and quickly made and represents all kinds of fuses.

3. *Knife Switches*—There is an endless variety of knife switch symbols. The English symbols are the simplest, easiest to make and indicate the live and dead side of the switch. This is accomplished by designating the terminals as a black circle on the dead side of the switch and as a full circle on the live side. The adoption of this method is recommended.

4. *Oil Switches*—Oil switch symbols are innumerable. It is recommended in the interest of simplicity that exactly the same symbol be used for oil switches as knife switches, with the addition of a rectangle or square around the whole switch, including the terminal, following the same method as indicating live and dead side.

5. *Resistances*—The symbol for resistance is usually a zigzag line, although there seems to have crept in a modification of this, which is evidently intended to represent an iron grid. The committee recommends that this be



abandoned and the simple zigzag line be used for all resistances.

6. *Adjustable Resistances*—Adjustable resistance to be similar to resistance with indication of traveling shoe, as shown. The use of these two symbols should be confined to diagrammatic representations of resistances separately used or in circuits and should have no indication of the type of resistance which is under consideration.

7. *Rheostat*—As it is sometimes desirable to indicate the presence of a rheostat as a piece of apparatus, the committee recommends the adoption of the symbol as shown.

8. *Reactance*—This was found to be universal, and the

adoption is recommended of the well-known symbol as shown in No. 8, with the addition of a sliding shoe when necessary to indicate that it is adjustable.

9. *Lights*—Incandescent lamp as shown. Arc as shown.

10. *Drum Controller*—As shown.

11. *Motors.*
12. *Generators.*
13. *Converters, etc.* There seems to be no uniformity whatever in the symbols indicated for these common types of machinery; they vary from elaborate pictures to diagrams, showing the internal connections to a simple circuit with the initials. The committee recommends that the English symbols be adopted, as in all cases it is evident from the symbol what the machine is. This in a measure follows recommendations for meter symbols.

14. *Batteries*—The conventional symbol for batteries is well known; it is recommended that its use be continued. However, there should be a simple means of designating either a primary or secondary battery and the following is suggested: Primary batteries to be indicated by parallel light and heavy lines; secondary batteries by the same with the addition of a rectangle, as shown.

15. *Condensers*—As shown.

16. *Circuit Breakers*—There are many symbols in use for circuit breakers, one an elaborate drawing of the circuit breaker. Example, that of the Patent Office. There is a tendency in others to show the kind of contacts. It is believed this should be simplified and several symbols be adopted for the various types of circuit breakers. The committee makes no recommendations for these at the present time.

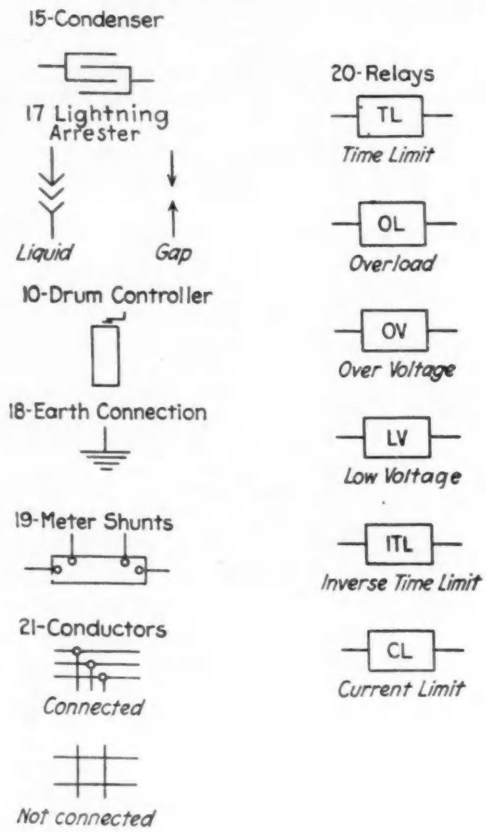
17. *Lightning Arresters*—Two symbols recommended for lightning arresters, one for liquid cell and the other for the gap, as shown.

18. *Earth Connection*—As shown.

19. *Meter Shunts*—As shown.

20. *Relays*—The representation of relays by symbols is in practically the same state as circuit breakers, and the committee recommends that the same system for relays be adopted as shown for meters, with the exception that a rectangle be substituted in place of the circle and sufficient letters added to indicate type and function of the relay.

21. *Conductors Crossed Without Making Contact and Conductors Making Contact*—As shown.



COMMENTS ON SYMBOL STANDARDIZATION

Above are suggested symbols for the details of electrical circuits. On page 240 of the October, 1917, issue of THE JOURNAL appears a list of symbols for mechanics and hydraulics proposed by the Committee on Technical Nomenclature of the Society for the Promotion of Engineering Education.

Both of these sets of symbols were submitted to the members of the S. A. E. Standards Committee, with requests for constructive criticism. From the replies which have come in to date the following comments are quoted.

Space will not permit giving the replies in full, or of even referring to the comments that are of a general nature. However, it can be stated that nearly all the replies commend the idea of symbol standardization as a means of simplifying teaching and of saving time for those who read technical literature and refer to technical textbooks and reference books.

ELECTRICAL CIRCUIT SYMBOLS

"The motor symbol in 11, 12, 13, etc., should show sliding brushes (that is, hook-shaped terminations to the wires) for the D. C. connections, instead of solid brushes, inasmuch as the sliding brushes are easier to draw, and cannot be mistaken for A. C. connections, as might be the case with the suggested D. C. symbols should the heavy black part of the brush be carelessly drawn."

"It is recommended to insert a small x in the center of the circle representing incandescent lights (symbol 9), inasmuch as the circle is also used for several other symbols, such as connections between conductors, terminals, etc.

"Referring to the wiring diagram, symbol 21, the old style of bridging across was plain and simple and satisfactory."

All of the above suggestions are worthy of serious consideration, and it is hoped that any further suggestions for changes in or additions to the list will be submitted to the Society promptly, in order that they may in turn be transmitted to the bodies which have these matters under advisement.

MECHANICS AND HYDRAULICS SYMBOLS

"With reference to v for linear velocity and V for volume, there is opportunity for confusion, in view of the fact that in the aeronautical field at the present time several very highly specialized works have been written in which the symbol V is used to denote velocity. Moreover, this symbol is so used to as great an extent as in any other branch of mechanical science."

"The Greek letter alpha (α) for angular acceleration

is too nearly like the letter *a*, the symbol for linear acceleration."

"Inasmuch as the capitals *HP* have always been used in the past to designate horsepower, we believe this would be better than the new symbol suggested (H_p)."

"It would be less confusing to employ the Greek letter Mu (μ) instead of *f* to denote coefficient of friction, as *f*, in mathematics, is the symbol for 'function,' and many textbooks on mechanics employ it for denoting deflection of beams."

"Capital *E* is preferable to small *e* for expressing efficiency, as *e* is already needed to denote eccentricity of load; it has other significations, as well in mechanics as elasticity, and coefficient of restitution. In thermodynamics, the numerous efficiencies are all designated by *E* as a capital letter. Efficiency is the ultimate resolution of every engineering problem, and therefore merits a capital letter symbol."

"Instead of small *w*, the Greek letter Omega (ω) is advisable for angular velocity. In mechanics it is universal, and confusion would be caused by changing it; besides, small *w* is frequently used in books on mechanics and strength of materials to designate unit load."

"The following changes are suggested: Substitution of I_p for *J* for the polar moment of inertia, and the substitution of the Greek letter Rho ρ for the radius of gyration instead of *k*."

"There appears to be an undue aversion to Greek symbols, only one being included in the whole list. A considerable portion of the Greek alphabet is in common enough use among engineers to justify their retention as a standard, and the substitution of *w* for ω and *f* for μ, for angular velocity and coefficient of friction respectively, can only be viewed with misgivings; *w*, in particular, should be retained to denote a subsidiary weight, or increment to the weight *W*."

"From an aeronautical standpoint, *T* is the accepted symbol for propeller thrust, *Q* being used for torque in this connection, and it seems that if it is desired in some quarters to keep *T* for torque the aeronautical notation should at least be put forward as an alternative."

NOTE.—In the original list, published in THE JOURNAL last October, there were two typographical errors, viz.: The use of capital *Y* as the symbol for deflection of beam, and the use of alpha α for angular acceleration. For the former symbol, small *y* should be substituted, and α should be omitted, as this symbol was not finally agreed upon by the committee.

Development of War Tanks

THE Machine Gun Corps of the British Army as constituted in October, 1915, was divided into an infantry, a cavalry, and a motor branch, according to an article in *The New York Times*. Six months later a new section was formed at Bisley. The men for this new section were taken from the pick of the Derby recruits; for the junior officers two Colonels went on a voyage of discovery to cadet battalions and other units and selected promising young men with a knowledge of internal combustion engines who had given proofs of an adventurous spirit and of ability to make men move.

The name given to the new organization—the Heavy Armored Section of the Motor Machine Gun Service—only deepened the mystery, as there were no signs of cars, armored or unarmored, and the only training given to the men was foot drill and machine gun practice.

At first sight the armored car appeared little more than a huge shapeless bulk of metal. It was said to weigh some forty tons, was armor-plated all over, with tiny spyholes at intervals, from some of which peeped out murderous-looking gun muzzles, and had no visible means of progression except two small motor wheels attached like a tail behind. The wheels behind were found to act only as a rudder to direct its course, the propulsive force coming from some internal and invisible wheels that traveled over long endless metal tracks, extending in an elliptical shape from the snout to the rump and moving forward as the creature advanced. The pace at which this strange object moved was slow—barely three miles an hour.

In the autumn of 1914, when the opponents had settled down to trench warfare, it became obvious that some means of parrying the danger of well-directed and well-protected machine gun fire from the German trenches must be discovered if our infantry were to carry out assaults with success. The idea of a self-propelled armored car which could move unscathed over unprotected ground, could crush down wire entanglements, and carry guns with a crew to work them, occurred to several people both in the army and the navy. Such an engine, recalling the turris mobilis of Livy and the beffroi of the Middle Ages would not only be able to tackle troublesome machine guns in the German trenches, but would also help to clear a way through barbed wire obstacles for the infantry.

Among the earliest of the more practical suggestions was one by Colonel Swinton, the first commanding officer of the "Heavy Section," in October, 1914, to build armored cars on the Holt tractor system, an American invention, or on a similar caterpillar principle, to smash through wire entanglements and climb trenches. This idea was subsequently referred to the Committee of Imperial Defense and the War Office, and experiments with various tractors were made on behalf of the War Office, for some time without practical result. In the meantime a similar idea had occurred to officers in the Royal Naval Air Service, and Mr. Churchill, then First Lord, took it up warmly.

When in June, 1915, the Commander in Chief in France sent in a memorandum urging an exhaustive examination of the question, two State departments chiefly concerned had the matter well in hand. Moreover, the Ministry of Munitions, which had recently been established, was also considering the matter. Through the medium of the Committee of Imperial Defense the various efforts for the solution of the problem were coordinated, and a committee, of which Mr. Churchill was a member, was appointed to decide on the distribution of the work.

According to the recommendation of this committee the War Office laid down the conditions that had to be fulfilled by the car. It should be able to climb a 5-ft. parapet and cross a 10-ft. ditch; in weight and width it

had to conform to the measurements of standard War Office bridges and to railway transportation requirements, and it must not be too high, for reasons of visibility to the enemy; it must be protected against close-range rifle and machine-gun fire, and it must be able to destroy machine-gun emplacements. It was agreed, however, that the first experimental work should be left in the hands of the Admiralty Committee.

A year was spent by the Admiralty Committee in researches and experiments before a satisfactory machine was designed and constructed. Finally, from among the tractors inspected the most satisfactory was found to be a caterpillar tractor with an endless self-laid track, over which internal driving wheels could be propelled by the engines.

The construction of these new engines of warfare was still necessarily a slow business. Improvements were continually being adopted, which necessitated changes in the original designs, and men had to be specially trained in the factories for the work required. It was not, therefore, as we have seen, till about July, 1916, that the first consignment arrived at the secret manoeuver ground to meet the personnel which was to use them.

The new machines, as delivered at the secret camp, were found to be of two slightly different designs. One, called the male, was armed with two Hotchkiss quick fire guns, with a subsidiary armament of some machine guns. These were especially designed for dealing at close quarters with the concrete emplacements for the German machine guns. The other type, called the female, was armed only with machine guns, and was more suitable for dealing with machine gun personnel and riflemen than with the emplacements.

The members of the Heavy Section of the Machine Gun Corps had to learn how to drive and steer them, to repair them, and to fire off their guns when boxed up within their narrow compass; they even had to learn how to live at all inside them. Imagine a narrow cabin some 9 or 10 ft. wide, 13 ft. long and 4 ft. high into which had to be crammed an engine of over 100 hp., two guns, and three or four machine guns, provisions for three days, ammunition and equipment, besides a crew of several men. The noise made by the engine made it impossible to hear an order, consequently every communication had to be made by signs; the armor plating was so effective that one could only see for steering or for aiming the guns through the narrowest chinks; the motion, too, of the tank over rough ground was not unlike that of a ship in a heavy sea, and this motion, combined with the smell of oil, the close atmosphere, the heat and the noise, was at first apt to induce the same symptoms as sometimes afflict those uninured to sea-voyages.

Two exhibition combats with tanks over the trench system were prepared, one being held before General Staff officers, the other before the King. These showed that the tanks answered the purposes for which they had been designed, and orders were given for them to be made ready for France. At the end of August fifty tanks were loaded at night on the railway at the camp's private siding and sent off to France with all due precaution for secrecy. They were landed at Havre on Aug. 29 and went up to the front, some by road, others by railway. The tanks sent over were painted all over for the purpose of concealment with weird colors which added to their grotesque appearance.

Tanks in Action

Detachments of tanks were assigned to the army commander engaged in the continuation of the Somme offensive. On Sept. 15 they were let loose for the test of battle.

The new offensive, which began on Sept. 15, was a continuation of the great battle of the Somme that had started in the previous July. The object of this offensive was to drive the Germans out of high ground running east and south of Thiepval, from which they could enfilade our newly gained positions. The Germans were strongly intrenched, and had hundreds of gigantic wasps' nests scattered about in the shape of strong concrete emplacements for machine guns. Bitter experience had taught our generals that a successful advance under cover of our artillery barrage into the first line trenches was too often doomed to be hung up by the concerted fire from these wasps' nests, which could not be reached by our infantry. The chief business of the tanks was to help our infantry by destroying these nests.

Sept. 15 was a misty morning and comparatively few of our troops saw the long line of tanks which the night before had been comfortably parked in a secluded valley, deploying into battle position. But when the mists rose and the tanks appeared to friend and foe in all their grotesque uncouthness, the effect was as exhilarating to us as it was dumbfounding to the Germans.

When the Germans had recovered their senses sufficiently they directed all the available rifle and machine-gun fire upon them. But the tanks did not mind. A war correspondent, describing the adventures of Crême de Menthe on the way to Courcelette, narrates that:

"The bullets fell from its sides harmlessly. It advanced upon a broken wall, leaned up against it heavily until it fell with a crash of bricks, and then rose on to the bricks, passed over them, and walked straight into the midst of factory ruins."

One tank in another part of the field was in action for twenty consecutive hours. Another, getting well ahead of the infantry, on finding itself alone, turned back to see what had become of its human companions. They were found to be held up by a machine-gun emplacement full of Germans, so the tank obligingly sat on the emplacement, shot down the Germans, and led the men on to further victories.

It must not, however, be imagined that the proceedings of the tanks were quite as amusing to those inside as they appeared to the British infantry, who had barbed wire leveled for them and machine gun emplacements crushed as they advanced. The cramped quarters, the head-splitting noise, and the difficulty of ascertaining what was going on outside made the lives of the tank crew anything but agreeable in battle. Their periscopes were apt to be shot away; the steering gear, never easy, became almost impossible. The mere manual labor of moving the levers of the engines and turning apparatus was enormous, especially in these early machines. The crew had difficulty in communicating with the outside world, and had to rely chiefly on two carrier pigeons taken with them on the voyage; as for communication with them by the outside world, this was even harder. The tank, indeed, proved to be an admirable protection against ordinary rifle bullets.

Even when the tanks themselves were knocked out this was not necessarily fatal to the crews, who often man-

aged to escape, and the casualties were small in proportion to the number of tanks put out of action. Those who inaugurated tank tactics in this first battle deserve all the credit they can receive.

Once having proved their value the tanks came to stay. Later in the year tanks were sent out to Egypt and were in action at Gaza. In November they were used again in France. Meanwhile more and more tanks were being constructed and an increasing personnel to form the crews and the repair sections were being trained in England. After the first success in France the growing importance of the organization was emphasized by a change of title from "Heavy Section" to "Heavy Branch of the Machine Gun Corps." Finally in July, 1917, the growing size and importance of the tanks organization justified the Army Council in entirely separating it from the Machine Gun Corps and establishing it as a special Tank Corps by itself under a Director General.

In France the tanks have been in action in successively increasing numbers at each attack delivered on a large scale. At Arras in April, at Messines in June, and at the third battle of Ypres in August they have continued their valuable work. They naturally have not enjoyed the advantages of surprise so useful in their first engagement, and it would not be expected that a vigilant enemy like the Germans would not contrive countermeasures. They have now established special observers and airplanes to watch for tanks and signal their appearance, and guns, both in the rear and in the trenches, to deal with them. Armor-piercing bullets are served out to their riflemen and machine gunners for use at close quarters, and elaborately concealed tank traps are prepared to engulf the monsters.

Current Standardization Work

THE following specifications for color and protective coatings for airplanes were recently proposed by a subdivision of the Aeronautic Division of the Standards Committee, headed by Dr. Percy H. Walker. These specifications are now receiving the consideration of the Aeronautic Division, which will be pleased to receive any criticism of a constructive nature from members of the Society:

Rapid Drying Color Coatings for Airplanes

(Tentative Specification)

1. The object of these specifications is to secure a high grade rapid drying coating for use on bare and varnished wood, "doped" or varnished linen, bare metal or metal coated with a baked black coating. The material usually found satisfactory for this purpose is composed of a high grade water resisting spar varnish in which there is finely ground an opaque light-resisting pigment in amount not exceeding 30 per cent by weight of the total paint. The user will specify whether olive drab, low visibility gray, light cream, aluminum or other color is desired.

2. The coating shall weigh not more than 9¾ lb. per gallon. Unless otherwise specified the material must be suitable for application by brushing on all of the following bare or varnished wood, "doped" or varnished linen, bare metal or metal coated with a baked black coating. It must match the standard colors prescribed by the users. It must give a rapid drying, smooth, elastic and durable coating, either in the condition delivered or by reducing according to explicit directions furnished by the manufacturer.

(a) It must show no excessive settling or hardening in the can, either as delivered or when reduced according to the manufacturer's directions for use. When flowed in condition as received or reduced according to manufacturer's directions for application on one side of a clear, clean glass plate, 10 by 15 cm. (4 by 6 in.) and held in a vertical position, and maintained at a temperature of 21 deg. to 32 deg. cent. (70 to 90 deg. fahr.), it should act to touch at a point not less than 2.5 cm. (1 in.) from the side or top edges of the film in not more than 2 hr. and shall dry hard in not more than 8 hr. to a hard and elastic film. This film must be so opaque that the filament of an incandescent electric light (40 watt Mazda) at a distance of 50 cm. (20 in.) cannot be seen through the glass at a point 5 cm. (2 in.) from the top of the film.

(b) Sheets of clean iron 10 cm. (4 in.) wide, 15 cm. (6 in.) long and about 0.4 mm. (0.016 in.) thick will be given a brush coat on one side, allowed to dry in a vertical position at a temperature between 15 deg. and 35 deg. cent. (60 and 95 deg. fahr.) for 24 hr. The coating shall not run or streak appreciably from the top edges and shall show an even, smooth opaque surface. A second coat will be applied one day after applying the first coat. This will be allowed to dry in a horizontal position, painted surface down, for 2 days. Some of the painted metal sheets will be kept in the dark, others in diffused light indoors, and others will be exposed out of doors at an angle of 45 deg. to the vertical, facing south, for a period of 6 days. Other plates will be placed under a gentle stream of tap water for 18 hr., lightly wiped to remove any deposit from the tap water. The coating must show no discoloration, softening or other defects. Other plates will be hung in boiling distilled water for 15 min. The coating on these plates must show only inappreciable discoloration, softening or other defects, either immediately after taking from the boiling water or after drying in the air.

The plates which have been exposed out of doors 6 days must match in color those kept in the dark and those kept in diffused light indoors. They must also stand bending double ten times over a rod 3 mm. (⅛ in.) in diameter with the painted side outside at a temperature between 21 deg. and 23 deg. cent. (70 and 75 deg. fahr.), without the coating showing any cracking or flaking.

Baked Black Protective Coating for Metal

(Tentative Specification)

1. The object of this specification is to secure a high grade coating to be applied by a baking process to metal parts used in airplane construction. The manufacturer

is given the greatest latitude in selection of raw materials and process of manufacture in order to produce the highest grade material.

2. Unless otherwise specified, the material must be suitable for application by dipping, either in the condition delivered or by reducing according to explicit directions furnished by the manufacturer. It must give after baking a smooth, elastic, black and durable coating, and must pass the following tests:

(a) A sheet of clean iron 10 cm. (4 in.) wide, 15 cm. (6 in.) long and about 0.4 mm. (0.016 in.) thick will be dipped for a depth of 14 cm. (5½ in.) in the sample (reduced according to manufacturer's direction if not originally furnished of dipping consistency) and hung in the air at a temperature between 15 deg. and 35 deg. cent. (60 and 95 deg. fahr.) for 1 hr. The coating shall not run appreciably from the top edge, and shall show an even, smooth surface.

(b) Similar sheets of clean iron dipped in a similar manner shall, after draining in a vertical position for 30 min., be placed in an oven at a temperature of 66 deg. cent. (150 deg fahr.). The temperature of the oven will then be uniformly raised so that it will reach the temperature specified by the manufacturer (not less than 150 deg. cent. (302 deg. fahr.) nor more than 205 deg. cent. (400 deg. fahr.) in not less than 1 hr. nor more than 2 hr., and thereafter maintained at that temperature. Some plates shall be removed when the prescribed baking temperature is reached, others 1 hr. thereafter and the remainder 2 hr. thereafter. These plates shall be cooled to room temperature and kept for 7 to 10 days. They must then stand bending double ten times over a rod 3 mm. (⅛ in.) in diameter without the outside coating cracking or flaking.

3. Application. Iron and steel fittings to be thoroughly cleaned to bare metal by sand blasting. The clean article to be dipped into the coating material which must comply with the specification for "Material for Black Baked Protective Coating for Metal" properly reduced, if such reduction is prescribed by the manufacturer. After dipping the articles to be suspended in the air until all free draining has stopped, in no case less than 20 min., they shall then be placed in the baking oven, which shall at this time have a temperature not above 66 deg. cent. (150 deg. fahr.). The temperature of the oven shall be raised in a period of not less than 1 hr. nor more than 2 hr. to the baking temperatures specified by the manufacturer, but which shall not be less than 150 deg. cent. (302 deg. fahr.) nor more than 205 deg. cent. (400 deg. fahr.) and maintained at this maximum temperature for a period specified by the manufacturer of the coating material, but which shall in no case exceed 1 hr. The articles shall then be removed from the oven.

In general, one coat will afford sufficient protection, but for parts subjected to unusually hard mechanical abrasion two coats may be applied. In such cases the method of application and material for the second coat shall be the same as for the first coat.

Air Drying Black Protective Coating for Metal

(Tentative Specification)

1. The object of this specification is to secure a high grade rapid drying coating to be applied to metal parts used in airplane construction where it is not possible to bake, or where baked parts have been damaged in assembling. The manufacturer is given the greatest latitude in selecting raw materials and process of manufacture in order to produce the highest grade material.

2. Unless otherwise specified the material must be suitable for application by brushing on to bare metal or metal coated with a baked protective coating, either in the condition delivered or by reducing according to explicit directions furnished by the manufacturer. It must give a rapid drying, smooth, elastic and durable coating and must pass the following tests:

(a) When flowed, in condition as received or when reduced according to manufacturer's direction for application, on one side of a clear, clean glass plate, 10 by 15 cm. (4 by 6 in.) and held in a vertical position and maintained at a temperature of 21 deg. to 32 deg. cent. (70 to 90 deg. fahr.) it shall set to touch at a point not less than 2.5 cm. (1 in.) from the side or top edges of the film, in not more than 5 hr. and shall dry hard in not more than 24 hr. to a hard, black and elastic film.

(b) Sheets of clean iron 10 cm. (4 in.) wide, 15 cm. (6 in.) long and about 0.4 mm. (0.016 in.) thick will be given a brush coat on one side, allowed to dry in a vertical position at a temperature between 15 and 35 deg. cent. (60 and 95 deg. fahr.) for 24 hr. The coating shall not run or streak appreciably from the top edge and shall show an even, smooth surface. A second coat will be applied two days after applying the first coat. This will be allowed to dry in a horizontal position, painted surface down, for two days. Some of the painted sheets will then be exposed out of doors at an angle of 45 deg. to the vertical, facing south, for a period of not less than 6 days. They must then stand bending double ten times over a rod 3 mm. (⅛ in.) in diameter with the coated side outside, without the coating showing any cracking or flaking. Other plates will be placed under a gentle stream of tap water for 18 hr., lightly wiped to remove any deposit from the tap water. The coating must show no whitening, softening or other defects. Other plates will be hung in boiling distilled water for 15 min. The coating on these plates must show only inappreciable whitening, dulling or other defects, either immediately after being taken from the boiling water or after drying in the air.

Tractor Division Meeting

THE meeting of the Tractor Division of the Standards Committee, held on the morning of Feb. 1 at the Hotel Sherman, Chicago, was devoted mainly to a general discussion of the work now being done by the division, such as the dimensions for punching driving-wheel rims, the condensed tractor specification form, tractor nomenclature, connecting-rod bearings, power-belt widths, steel and shafting sizes, screws and bolts, carbureter flanges, spark-plug shells, fuel and lubrication pipe fittings.

Punching of Driving-Wheel Rims.—If these punchings could be standardized, it was said that a lug could be made to fit any tractor wheel. On the other hand the opinion was expressed that the length should first be established and work from that to the lug. It is also necessary to consider the width of the rim.

The division had suggested that tractor rims be cut in even lengths, 12, 14, 16, 18, 20, 22 or 24 ft. In discussing this it was said that not a single wheel is now made using these recommended lengths. One wheel manufacturer is producing them 42, 48, 54 and 60-in. diameter, made in widths of 8, 10 and 12 in., any added width being obtained by putting on extensions.

The proposal to place the spokes at each 12 in. of rim length was also said to differ from the present practice in which small wheels have 16 spokes and the larger

wheels above 40 in. diameter, 24 spokes. The gear can then be fastened to the rim by using either three or four double lugs, making six or eight fastenings. Most tractor wheels are fastened to the wheel with some multiple of either six or eight attachments, and 24 being a common multiple falls in well with current practice.

The question was asked as to whether it was desired to conform the tractor standards to present practice or to adopt standards not now in use and let designers work to them in the future. In answer to this it was said that the purpose is to consider the standards thoroughly and formulate them so that they will conform to the best engineering practice now and will also be of use to a man who is designing for the future.

It was finally decided to add W. H. Worthington, of the Electric Steel Company, to the subdivision considering the matter of rim punching and refer the subject back for consideration. A. W. Scarret was designated to act on the subdivision in place of H. C. Buffington.

Condensed Tractor Specification.—This specification form was approved at the Annual Meeting of the Society held in New York in January but since that time it has been suggested that two or three items should be added to the form; one being the total weight on the drive wheels.

The question was raised as to what was to be the purpose of the specification; whether it would be used by the manufacturer, by the dealer in farm tractors, or by the farmer. The work being done by some of the farm papers in gathering tractor data was mentioned and the suggestion was made that the different publications should use the same list of questions, thus getting much better results in securing data from the manufacturers. It was said that the engineer is the only one who wants the detailed specification and might want answers for 160 questions, when the dealer would only want answers for 60 questions. It was finally voted to refer the matter back to the subdivision from which it originated with instructions to invite the cooperation of the farm paper publishers who are using similar forms.

Tractor Nomenclature.—It is considered necessary to agree upon some standard nomenclature for tractor parts so that the different companies can follow a definite practice in getting out catalogs. It was suggested at the meeting that the work done by the Committee on Nomenclature of the National Gas Engine Association, of which E. W. Roberts is chairman, be considered and that the automobile nomenclature adopted by the Society should also be referred to so that the names now applied to automobile work could be used for tractor parts whenever possible. The subject was referred back to the subdivision, with instructions to suggest a list of names for all the common parts of various types of tractors.

Connecting-Rod Bearings.—At the meeting of the division held in Minneapolis early in December, it was the consensus of opinion that the time was not yet ripe for the standardization of a series of sizes for connecting-rod bearings. It was felt that bearings really had to be made to meet the requirements of individual engines and therefore it would not be helpful to standardize sizes; further many manufacturers desire to supply their own parts, especially such important ones as connecting-rod bearings, in order to keep records that are extremely valuable in working out new designs. It was finally decided to have George T. Strite prepare a report on the advisability of standardizing such bearings for submission at the next meeting.

Power-Belt Widths.—The table of power-belt widths approved by the division at the December meeting (see page 385, December JOURNAL) was considered and it was suggested that the pulley-widths be made minimum, inasmuch as in running separator belts under bad conditions a more generous pulley space is often required. A question was raised as to whether the belt speed of 2600 ft. per min., which has been standardized by the Society, conformed with current practice. It was said that the N. G. E. A. had recommended three standard belt speeds, one for stationary engine work, one for the portable or small tractor engine that would operate largely corn huskers, and a third for the larger tractor that would operate grain-separating machinery. The speed of 2800 ft. per min. was recommended for the last, but it was said that most of the separators and machinery operated by tractors run at a speed of about 2600 ft., which was thought to be correct. The subdivision was asked to take the matter up further with the manufacturers in order to obtain the best widths of power belts.

Steel and Shafting Sizes.—There was considerable discussion as to the use of S. A. E. steel specifications for tractor purposes. A sub-committee of the Engineering Practice Committee of the Minneapolis Section has suggested that certain new compositions be recommended for tractor purposes with the view of eliminating some of the present standard specifications. Specifications for cold-rolled steel were suggested in order to obtain material of some definite hardness and carbon content. There seemed to be no objection to the present S. A. E. steels, but a change was thought desirable in order to lessen the number of compositions. It was finally decided to refer the suggested specifications to the subdivision on steel and shafting sizes in order to secure further information from steel manufacturers and at the same time to ask the Iron and Steel Division of the Standards Committee to consider the possibility of eliminating certain of the present steel specifications.

Screws and Bolts.—The division recommends that the threads used on tractors shall be the United States Standard or S. A. E. Standard in the sizes given in the S. A. E. Handbook, eliminating the one-sixteenth sizes about ½-in. diameter.

Carbureter Flanges.—It was suggested that some of the S. A. E. standard flanges for tractor practice might be eliminated. It is believed that the ½ and ⅝-in. flanges, the ¾ and ⅞-in., the 1¼ and 1½-in., are so nearly the same size that one of each of them could be eliminated. This proposal will be presented to the carburetor and engine manufacturers for consideration.

Spark-Plug Shell Dimensions.—The division had previously recommended that the metric thread plug be used for tractor practice, but on further investigation it has been found that the S. A. E. Standard plug is in more general use. Experiments are now being conducted to show which is the better for tractor purposes. It is expected that a report on these experiments will be presented at the next meeting of the division.

Fuel and Lubrication Pipe Lines.—The possibility of supplying a union that can be used on tractors, motorcycles, aircraft, and automobiles was discussed. A standard might be settled upon to be used in the tractor, passenger and commercial automobiles, and in the motorboat industries, but possibly a different construction would be required for aircraft. It was finally decided to take the matter up further with the manufacturers of unions in order to determine the best practice for the different forms of vehicles.

Activities of S. A. E. Sections

MOST of the sections are now electing nominating committees, which, in accordance with the section constitutions, must prepare a complete ticket for section officers at least 45 days prior to the annual election. Inasmuch as the present administration year for all the sections extends from May 1 to April 30, it is probable that the annual business meeting will be held some time during April, and thus the report of the Nominating Committee must be presented during the month of March. The Metropolitan Section has designated as its Nominating Committee David Beecroft (chairman), Harold W. Slauson and H. V. R. Scheel. The Minneapolis Section Nominating Committee is as follows: A. C. Bennett (chairman), J. E. Nead, Leonard Nelson, H. W. Adams, C. C. Cavanaugh and James Gemlo. The Cleveland Section has chosen A. J. Scaife (chairman), G. S. Case, John McGeorge and C. S. Pelton as its Nominating Committee.

The Buffalo Section presented a paper at the meeting of the Buffalo Engineering Society, held Feb. 6, in Buffalo, C. C. Carpenter, chief chemist of the United States Light and Heating Corp., giving a paper on electric-storage batteries. Mr. Carpenter showed a number of plates and batteries, and his talk was illustrated by diagrams and photographs.

The next meeting when the Buffalo Section will give a paper will be on March 20, and W. M. Corse of the Titanium Alloy Mfg. Co., Niagara Falls, will discuss the subject of bronzes.

At the February meeting of the Cleveland Section, held on the 15th, O. W. A. Oetting of the Willard Storage Battery Company gave a paper on the effect of cold weather on automobile starting, which appears elsewhere in this issue.

The next meeting of the Cleveland Section will be held on the 15th of March. Mr. Tewksbury of the Cleveland Tractor Company will present a paper on general tractor development.

The meeting of the Detroit Section, held Feb. 21, was devoted to a discussion of the development of passenger-car and motor-truck construction during the last year. A paper was presented by J. Edward Schipper of the Class Journal Company. Motion-picture films were shown of the Liberty motor truck and of tractors designed for war service.

At the March meeting of the section the Body Division of the Industrial Research Committee of the Section, consisting of Paul E. Kelecom (chairman), E. W. Goodwin, John Allmand, L. C. Hill and C. H. Wilson, will deliver a paper.

At the meeting of the Indiana Section, held on the 8th of February, Carl H. Schell, chief engineer of the Thermoid Rubber Company, discussed the subject of flexible universal joints. The next meeting of the section will be held March 1, when C. E. Sargent, chief engineer of the Lyons-Atlas Company, will give a paper on fuels.

Prof. J. L. Mowry of the engineering department of the Minnesota Farm School addressed the Minneapolis Section on Feb. 6 on the subject of tractor fuels. At the next meeting of the section, to be held on March 6, it is expected that F. McDonough of the Toro Motor Company will speak on hydraulic transmissions.

The Metropolitan Section is not planning to hold a meeting during February but will resume sessions again in March with a meeting, the subject of which will be announced later.

At the Jan. 18 meeting of the Mid-West Section, held at the Chicago Automobile Club, Secretary Darwin S. Hatch read the following letter from Winfred D. Gerber:

"The Illinois Society of Engineers, of which I have the honor of being president, has attempted on several occasions to impress upon public officials the desirability of appointing qualified engineers to public positions wherein engineering training and experience would be a valuable asset.

"Numerous failures along this particular line have convinced me that cooperation among the engineering societies of this State, in the form of an affiliated engineering society of Illinois, would get us the consideration that we are now unable to secure as individual organizations.

"May I suggest that you take this question up with your Society and ascertain if it meets with its approbation?

"The Illinois Society of Engineers has its annual convention next Thursday and Friday, Jan. 24 and 25, at Quincy, at which time I shall bring the matter before the Society with the recommendation that inasmuch as we are a State Society that we undertake the initiative and through a properly delegated committee, endeavor to secure the cooperation of all the engineering societies in this State.

"You can readily foresee where an affiliated organization, whose membership is limited to delegates from each Society, will have great power in bringing about publicity for engineering."

After discussion, the Mid-West Section adopted a resolution to cooperate with the engineering societies.

C. J. P. Lucas presented a motion in the following words: "Every man who enters the service of the United States makes a great sacrifice for us, knowing he upholds the duty he owes his country, and we who stay at home and work should vote to suspend the dues and back up that man, otherwise we are not fit to be citizens of the United States. I move that we consider the dues suspended of every man who enters the service, directly or indirectly, and cannot attend the meetings." The motion was seconded and carried.

At the Feb. 21 meeting of the Mid-West Section, the subject under discussion was Automotive Interests. First Vice-President Beecroft approached it from the view-point of the Society and Dent Parrett from that of the tractor manufacturer. In addition a paper on the Economical Size of Tractor, by Ernest Goldberger, was scheduled for this meeting. The March meeting will be held on the 20th.

The Pennsylvania Section planned to hold a meeting devoted to upholstery as affecting easy riding, in January, but on account of the illness of the author it was necessary to postpone it. The Section has now planned to hold this meeting on the 28th of February, in Philadelphia; Watson R. Smith of the Jackson Cushion Spring Company will read the paper.

REPORT OF CHICAGO COUNCIL MEETING

A meeting of the Council was held Jan. 31, at Chicago, with President C. F. Kettering, First Vice-President David Beecroft, Second Vice-President C. C. Hinkley, and Councilors B. B. Bachman, H. L. Horning and J. V. Whitbeck present.

President Kettering announced the appointment of the following Finance Committee for the current year: H. M. Swetland, chairman; Hugh Chalmers, Christian Girl, George H. Houston and Henry R. Sutphen.

Mr. Beecroft reported that all arrangements had been completed for the Chicago meeting and dinner, that four papers were to be read at the professional session, also that a dinner and meeting were to be held at the Hotel Baltimore, Kansas City, Feb. 13, during the National Tractor Show, at which addresses would be delivered on tractor standardization and on other tractor engineering subjects.

President Kettering appointed the following Meetings Committee to serve during the year: David Beecroft, chairman; Leonard Kebler, C. F. Scott, F. E. Place and E. R. Greer.

It was voted to make the following transfers in grade of membership: From Associate to Member Grade, Bruno Schroeter and Harold E. Talbott, Jr.

Applicants to the number of 16 were elected to membership in the Society, these being assigned to grades as follows: 5 Members, 5 Associate Members, 2 Junior Members, and 4 Student Enrollments.

The constitutional amendments proposed at the Annual Meeting of the Society were referred to the Membership Committee, with the request that it confer with the Constitutional Committee on any changes considered necessary, a report thereon to be made at the next meeting of the Council.

President Kettering announced the appointment of the following Publication Committee: Daniel Roesch, chairman; W. A. Chryst, David Fergusson, E. R. Greer and G. C. Loening.

Second Vice-President Hinkley was appointed chairman of the Membership Committee.

Councilor Bachman was made chairman of the Standards Committee for the present year.

The Council approved amendments to Paragraphs SC-1 and SC-8, adopted by all the sections of the Society. These two amendments relate to the change of name from automobile to automotive.

President Kettering appointed the following Sections Committee for the coming year: Councilor C. S. Crawford, chairman; R. J. Nightingale, Leonard Kebler and R. H. Combs.

A Constitutional Committee was authorized by an amendment to the Constitution adopted at Washington last June, and President Kettering announced the appointment of the following: Councilor B. B. Bachman, chairman, to serve one year; Councilor J. V. Whitbeck, to serve two years; David L. Gallup, to serve three years.

President Kettering announced the appointment of a House Committee as follows: George W. Dunham, chairman; Julian Chase, William P. Kennedy and Frederick R. Hutton.

The next meeting of the Council will be held Feb. 25, at Dayton, Ohio.

PERSONAL NOTES OF THE MEMBERS

Nicholas L. Baker, formerly superintendent, Auto Electric Service Co., Detroit, is now service engineer, United Electric Service Co., Detroit.

D. W. Burke, formerly superintendent, Auto Division, Westinghouse Elec. & Mfg. Co., Pittsburgh, Pa., has now purchased the Auto Electric Service Co. of Detroit.

L. W. Brownrigg, formerly sales engineer, National Carbon Co., Cleveland, is now with the R. B. Randall Electric Co., Inc., Kansas City, Mo.

C. R. Burt, formerly assistant general manager, Russell Motor Car Co., Ltd., Toronto, Canada, is now general manager, Russell Motor Car Co., Inc., Buffalo.

Herbert C. Berry, formerly designer and chief draftsman, Line Drive Tractor Co., Milwaukee, is now with the National Tractor & Machine Co., Chicago.

Willis D. Cook, formerly chief draftsman, Fuller & Sons Mfg. Co., Kalamazoo, Mich., is now engineer, Tractor Bearing Division, Hyatt Roller Bearing Co., Chicago.

B. J. Cline, vice-president and director of manufacturing, Supreme Motors Corp., Cleveland, is now general superintendent, Aero Division, Nordyke & Marmon Co., Indianapolis.

Dr. R. H. Cunningham, formerly chief electrical engineer, Splitdorf Electrical Co., Newark, N. J., is now electrical and ignition consulting engineer, New York.

J. M. Cook, formerly engineer with Hercules Motor Mfg. Co., Canton, Ohio, is now with Canton Auto Parts Mfg. Co., Canton, Ohio.

Ladislas d'Orcy, formerly aeronautical engineer, Gardner Moffat Co., Inc., New York, is now associate editor, *Aviation and Aeronautical Engineering*, of the same company.

Arthur M. Dean, formerly chief engineer, Ferro Machine & Foundry Co., Cleveland, is now chief engineer and vice-president, The Templar Motors Corp., Cleveland.

Garth A. Dodge, formerly factory manager and engineer, The Dayton Rubber Mfg. Co., Dayton, Ohio, is now with the Kelly-Springfield Tire Co., Buffalo.

Donald W. Douglas, formerly aeronautical engineer, Aviation Section, Signal Corps, Washington, is now chief engineer, Glen L. Martin Co., Cleveland.

E. M. Elliott, formerly manager, Department of Labor, U. S. Public Service Reserve, Washington, is now assistant factory manager, Wright-Martin Aircraft Corp., New Brunswick, N. J.

Raymond M. Everhard, formerly final tester and inspector of autos, M. C. Kale & Co., LaPorte, Ind., is now engine expert, Oldsmobile Motor Co., Chicago.

Joseph W. Gardham, Jr., formerly technical representative, Chalmers Motor Co., Detroit, is now in charge of tests, experimenting with motor trucks, The Militor Corp., Jersey City, N. J.

Eldon P. Gundry, formerly layout draftsman, Nash Motors Co., Kenosha, Wis., is now with the Oakland Motor Car Co., Pontiac, Mich.

W. E. Hamilton, formerly at Indianapolis, is now with the Standard Parts Co., Cleveland.

Frank A. Hayes, formerly engineer, Willys-Overland, Ltd., Toledo, Ohio, is now chief engineer Willys-Overland, Ltd., W. Toronto, Canada.

Louis Illmer, formerly chief engineer Simon Lake, Milford, Conn., is now with American Whaley Engine Co., Boston.

Royal K. Johnson, formerly consulting engineer, Cleveland, is now director of engineering, The Minerva Engine Co., Cleveland.

Arthur E. Jacobs, formerly body engineer, Commercial Vehicle Motors Co., Chicago, is now production engineer, R. & V. Wagner Ordnance Co., E. Moline, Ill.

R. Karasinski is now with The Templar Motors Corp., Cleveland.

Ralph R. Lapointe, formerly works manager, Lapointe Machine Tool Co., Hudson, Mass., is now works manager, The J. N. Lapointe Co. of Mass., Hudson, Mass.

Henry C. Limbach, formerly production manager, Zenith Carburetor Co., Detroit, is now salesman and equipment engineer, Strong, Carlisle & Hammond Co., Detroit.

William V. Lowe, formerly in the engineering department, John Bath Co., Worcester, Mass., is now in the engineering department, Deane Machine Co., Fitchburg, Mass.

L. J. Miley, formerly western manager, Asbestos & Rubber Works of N. J., at Camden, N. J., is now branch manager, Russell Mfg. Co., Middletown, Conn., at Chicago.

J. J. Martin, formerly assistant chief inspector, Premier Motor Corp., Indianapolis, is now production and designing engineer, Shotwell Pump & Tank Co., Indianapolis.

F. C. Manning, manager and president, Sumter Electrical Co., Chicago, is now general sales manager, Splitdorf Electrical Co., Newark, N. J.

LeRoy F. Maurer, formerly factory manager, Gillette Motors Co., Mishawaka, Ind., is now with the Studebaker Corp., South Bend, Ind.

D. M. Power, formerly engineer with Buick Motor Co., Flint, Mich., is now designing and consulting engineer, Detroit.

D. T. Randall, formerly with Cadillac Motor Car Co., Detroit, is now engineer, experimental department, Lincoln Motor Co., Detroit.

John J. Rooney, formerly at New York, is now aeronautic engineer, Briggs Aeroplane Co., Alexandria, Va.

Joseph A. Steinmetz, president of the Aero Club of Pennsylvania, is one of the directors of the new Y. M. C. A. School of Airplane Construction which has recently been started at 717 North Broad Street, Philadelphia. The purpose of this school is to assist in the aircraft production program by developing skilled labor that can be utilized in factories throughout the country.

G. B. Stone, formerly sales engineer, Remy Electric Co., Anderson, Ind., is now manager, tractor equipment division, with the same company at Chicago.

I. D. Shaw, formerly with Cincinnati Ball Crank Co. at Detroit, is now with the Automotive Mfg. Co. at Detroit.

William D. Sargent, president, Bayonne Steel Casting Co., Bayonne, N. J., is now vice-president, International Motor Co. of N. Y., at Newark, N. J.

W. Whitney Slaght, formerly student, University of Michigan, Ann Arbor, Mich., is now experimental engineer, Pierce-Arrow Motor Car Co., Buffalo.

Albert I. Stevens, formerly branch manager, N. Z. Graves Co., Inc., is now with the Oxford Varnish & Paint Co., Detroit.

H. A. Soulis, formerly production and equipment engineer, Maxim Munitions Corp., Derby, Conn., is now designer, The Militor Corp., Jersey City, N. J.

William Taylor, formerly assistant chief engineer The Militor Corp., New York, is now at Jersey City, N. J., with the same company.

Gordon E. Tucker has severed his connection as road engineer with the Zenith Carburetor Co., New York.

George N. Tobias, formerly engineer, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., is now treasurer, Auto Electric Service Co., Detroit.

Ernest Wooler, formerly automobile consulting and designing engineer, Cleveland, is now engineer, Chandler Motor Car Co., Cleveland.

Harry J. Walker, formerly steel salesman and specialist, Joseph T. Ryerson & Son, Chicago, is now with The Andrews Steel Co., Keyport, Ky.

John H. Weller, formerly superintendent, Whitney Mfg. Co., Hartford, Conn., is now factory manager, The Templar Motors Corp., Cleveland.

Honor Roll of Society Members

Anderson, Oscar G., private, 161st Depot Brigade, Co. 4, U. S. N. A. (mail) Barracks 1488W, Camp Grant, Ill.

Anderson, E. S., lieutenant, Aviation Section, Signal Corps, U. S. A., Gerstner Field, La.

Brown, Julian S., U. S. A. (mail), Aviation School, Massachusetts Institute of Technology, Cambridge, Mass.

Britten, Daniel L., captain, Ordnance R. C., Washington, assigned to Gun Division, Ordnance Section.

Chase, A. M., major, Ordnance Department, U. S. A., Washington.

Coe, Edw. M., first lieutenant, Quartermaster Corps, U. S. N. A. (mail), Mechanical Repair Shops No. 302, A. E. F., France.

DuBose, Geo. W. P., major, American Ordnance Base Depot, A. E. F., France.

Dahlquist, Chas. S., captain, Quartermaster Corps, U. S. N. A., Washington, assigned to Inspection Division.

Diamond, J. E., captain, Ordnance R. C., Peoria, Ill.

Duncan, A. C., first lieutenant, Balloon Co. No. 7, Signal Corps, Aviation Section, Signal R. C. (mail), A. E. F., France, via New York.

Duntley, Lloyd B., first lieutenant, Ordnance R. C., Washington, assigned to Engineering Motor Equipment Section.

English, C. H., Jr., first lieutenant, Ordnance R. S., Washington.

Franklin, G. King, captain, Motor Section, Ordnance R. C., Washington.

Fliedner, Carlyle, captain, Motor Section, Ordnance R. C., Rock Island Arsenal, Rock Island, Ill.

Getschman, G. F., second lieutenant, Ordnance R. C., Washington.

Graham, Louis, lieutenant, 309th Engineers, Engineers R. C., Camp Zachary Taylor, Ky.

Henderson, S. W., first lieutenant, Ordnance R. C., Washington.

Horine, M. C., second lieutenant, Aviation Section, Signal R. C., Washington.

Libbey, E. B., lieutenant, 2nd Caisson Co., 102nd Ammunition Train, U. S. N. A., Spartanburg, S. C.

McCormick, Bradley T., captain, Ordnance Department, U. S. A., New York.

McGill, Geo. E., Co. B., 85th Division Military Police, Camp Custer, Battle Creek, Mich.

Mason, Geo. R., lieutenant, A. E. F., France.

Orton, Edward, Jr., major, Quartermaster R. C., Washington, assigned to Motor Transport Branch, Engineering Section.

Purcell, Bernard A., captain, Quartermaster R. C., 307th Supply Train, Camp Gordon, Ga., assigned as Commanding Officer.

Rosenthal, Wm. C., sergeant, Engineer O. T. C., Camp Lee, Va.

Russell, Eugene F., major, Ordnance Department, U. S. A., Washington.

Streicher, Geo. A., 11th Co., Engineer O. T. C., Camp Lee, Va.

Scott, Allison F. H., captain, Signal Corps, U. S. A., Langley Field, Hampton, Va., assigned to Aviation Section as captain and post adjutant.

Sweet, Geo. P., first lieutenant, Signal Corps, U. S. A., Washington, assigned to Aviation Section.

Streeter, Robt. L., major, Ordnance Department, U. S. A., Rock Island Arsenal, Ill., in charge of truck and tractor experimental work.

Wodehouse, B. A., sergeant, 2nd Infantry Co., Officers' T. C., Camp Custer, Battle Creek, Mich.

Verity, Calvin W., captain, Ordnance R. C., Frankfort Arsenal, Philadelphia.

Yonkin, Harry F., first lieutenant, Ordnance R. C., A. E. F., France.

Civilian Service

Cherry, Ralph E., Signal Corps, U. S. A., McCook Field, Dayton, Ohio, assigned to Airplane Engineering Department.

Cleaver, B. J., Medical Corps, U. S. A., Fort Oglethorpe, Ga.

Clarke, Thomas A., Signal Corps, U. S. A., Washington, assigned to Aviation Section as production expert.

DuVal, Eugene C., Signal Corps, U. S. A., assigned to Airplane Engineering Department, Dayton, Ohio.

Eisele, William S., draftsman, Aviation Section, Signal Corps, U. S. A., Washington.

Millar, Thomas H., Jr., Quartermaster Corps, U. S. A., 205 Union Station, Washington, assigned to Motor Transportation Section.

Pollock, Ray C., Signal Corps, U. S. A., Buffalo, assigned as airplane engine inspector.

Seabury, W. M., Field Hospital, No. 337, Camp Custer, Battle Creek, Mich.

Searle, C. A., auto-parts inspector, U. S. A., Washington.

Williams, S. T., Naval Aircraft Factory, Navy Yard, Philadelphia, Pa., assigned as aeronautical mechanical engineer in Engineering Department.

Service Directory of Members

THE following list is intended to contain the names of all members connected with the Government either in the military services or in civilian capacities. The names are listed in two parts, the first showing the members who have actually entered the military services, and the second those engaged as civilians. Every effort is made to have the addresses correct, but many of the members are changing about so much that it is almost impossible to tell accurately as to just where they are located at any given time. It is therefore requested, in case of any error, that the member concerned immediately inform the New York office of the Society, so that a proper correction can be made. Members who have actually entered the service in any capacity, and who are not listed, should also write the details to the New York office.

Military Honor Roll

Alden, Herbert W., major, Motor Equipment Section, Carriage Division, Ordnance R. C., A. E. F., *France.*

Aldrin, Edwin E., lieutenant, Coast Artillery Corps, U. S. A., *Ft. Monroe, Va.*, (mail) 2nd Training Co., *Ft. Monroe, Va.*

Amon, Carl H., Aviation Section, Signal R. C., *Washington.*

Anderson, William C., lieutenant, Engineer R. C., *Brooklyn, N. Y.*

Arnold, Bion J., lieutenant colonel, Signal R. C., *Washington.*

Barker, C. Norman, pilot cadet, Royal Flying Corps, *Camp Borden, Can.*

Barton, W. E., first lieutenant, Quartermaster R. C., *Washington.*

Bibb, John T., Jr., private, Aviation Section, Signal Corps, A. E. F., France; (mail) 3rd Foreign Detachment, Cadet Flying Squadron, A. E. F., *France.*

Blank, M. H., first lieutenant, Motor Equipment Division, Ordnance R. C., *Washington.*

Blood, Howard E., lieutenant, Engine Design Section, Equipment Division, Signal Corps, U. S. A., *Washington.*

Boggs, Geo. A., lieutenant, Quartermaster Corps, U. S. A.; (mail) Farmers Loan & Trust Co., *Paris, France.*

Bowen, C. H., captain, Military Truck Production Section, Office of Quartermaster General, *Washington.*

Britten, Wm. M., major, engineer of Motor Transportation, Officer in Charge of Transportation, Quartermaster R. C., *Washington.*

Brown, Harold Haskell, first lieutenant, Coast Artillery Corps, U. S. N. A., *Fort Totten, N. Y.*

Browne, Arthur B., captain, Sanitary Corps, U. S. N. A., (mail) General Motors Co., *Detroit.*

Callan, John Lansing, lieutenant, Reserve Flying Corps, U. S. N., U. S. S. Seattle, (mail) Postmaster, *New York.*

Campbell, Lindsey F., 4th Battery, 2d P. T. R., *Fort Sheridan, Ill.*

Clark, Edward L., first lieutenant, Signal R. C., McCook Field, *Dayton, Ohio.*

Clark, Virginius E., lieutenant colonel, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

Coe, Edw. M., first lieutenant, Quartermaster Corps, U. S. A., *Washington.*

Dayton, William E., private, 306th Regiment, Field Artillery, U. S. N. A., *Washington.*

Deeds, Edward A., colonel, Equipment Division, Signal Corps, U. S. A., *Washington.*

De Lorenzi, Ernest A., officer, Mechanical Transport, War Department, *London, Eng.*

De Witt, George W., lieutenant, U. S. Naval Militia, *Jacksonville, Fla.*

Dickey, Herbert L., captain, Motor Equipment Section, Carriage Division, Ordnance R. C., *Washington.*

Dimond, G. A., first lieutenant, Motor Section, Ordnance R. C., Ft. Herring, *Peoria, Ill.*

Donaldson, Frank A., captain, Carriage Division, Ordnance R. C., Sixth and B. Sts., *Washington.*

Dost, Charles O., first lieutenant, Aviation Section, Signal Corps, U. S. A., Cornell University, *Ithaca, N. Y.*

Du Bose, Geo. W. P., major, American Ordnance Base Depot, A. E. F., *France.*

Earle, Lawrence H., first lieutenant, Ordnance R. C., assigned as inspector of ordnance, Holt Mfg. Co., *Peoria, Ill.*

Eells, Paul W., lieutenant, 330th Field Artillery, Artillery R. C., Camp Custer, *Battle Creek, Mich.*

Farrell, Matthew, captain, Quartermaster R. C., *Washington.*

Finkenstaedt, Edward R., captain, Military Truck Production Section, Office of Quartermaster General, *Washington.*

Fishleigh, W. T., major, Sanitary Corps, U. S. N. A., *Washington*, assigned as automobile engineer.

Flanigan, E. B., Officers' Reserve Training Camp, *Plattsburg, N. Y.*

Forrer, J. D., captain, Engineer R. C., *Washington.*

Foss, Clarence M., captain, Ordnance R. C., Rock Island Arsenal, *Rock Island, Ill.*, assigned to Motor Section.

Fox, Rudolph H., first lieutenant, Ordnance R. C., *Washington.*

Furlow, James W., lieutenant colonel, Quartermaster Corps, U. S. A., *Washington*, assigned to Office of Quartermaster General.

Gaebelein, Arno W., lieutenant, Ordnance R. C., *Washington*, assigned to Carriage Division.

Gardner, Lester D., captain, 117th Aero Squadron, Signal Corps, U. S. A., *Washington.*

Gey, William, 377th Truck Train, U. S. N. A., Camp Merritt, *Tenafly, N. J.*

Gfrorer, A. H., first lieutenant, Ordnance R. C., *Washington.*

Gillis, Harry A., major, Ordnance R. C., *Washington.*

Glover, F. S., major, Ordnance R. C., *Washington.*

Gorrell, Edgar S., lieutenant colonel, Aviation Section, Signal Corps, U. S. A., *Washington.*

Gray, B. D., major, Equipment Division, Aviation Section, Signal R. C., *Washington*.
Green, Geo. A., captain, Tank Section, British E. F., *France*.
Guthrie, James, major, Ordnance R. C., *Washington*, assigned to Field Artillery Section, Carriage Division.
Haeske, F. C., lieutenant, U. S. A., Camp Sherman, *Chillicothe, Ohio*.
Hall, Elbert J., major, Engine Design Section, Engineering Division, Signal Corps, U. S. A., *Washington*.
Hall, Richard H., Jr., first lieutenant, Quartermaster Corps, U. S. N. A., *Chevy Chase, Md*.
Harms, Henry W., captain, Aviation Section, Signal Corps, U. S. A., *Washington*.
Hartman, A. A., private, U. S. N. A., Camp Devens, *Ayer, Mass*.
Hegeman, Harry A., major, Quartermaster Corps, U. S. A., *Washington*, assigned to office of Officer in Charge of Transportation.
Hoffman, Roscoe C., captain, Carriage Division, Motor Equipment Section, Ordnance R. C., *Washington*.
Horner, Leonard S., major, Equipment Division, Signal Corps, U. S. A., *Washington*.
Howard, Walter S., first lieutenant, Military Truck Production Section, office of Quartermaster General, *Washington*.
Hubbell, Lindley D., major, Ordnance R. C., *Springfield, Mass.*, assigned as Officer in Charge, Hill Shops, Springfield Armory.
Jeffrey, Max L., first lieutenant, Military Truck Production Section, Office of Quartermaster General, *Washington*.
Jennings, J. J., first lieutenant, Quartermaster R. C., A. E. F., *France*.
Joy, Henry B., major, Aviation Section, Signal R. C., *Washington*.
Kendrick, John F., Signal Corps, A. E. F., *France*, assigned to Research Inspection Division.
Kennedy, H. H., lieutenant, Ordnance Department, U. S. A., *Washington*, assigned as inspector of ordnance.
Kline, H. J., first lieutenant, Ordnance R. C., *Washington*, assigned to Anti-Aircraft Section, Carriage Division.
Kohr, Robert F., second lieutenant, Engineers R. C., *Washington*.
Kottnauer, Edwin H., first lieutenant, Ordnance R. C., assigned to The Nash Motors Co., *Kenosha, Wis*.
Lane, Abbott A., first lieutenant, Aviation Section, Signal R. C., *Detroit, Mich*.
Lanza, Manfred, major, Quartermaster Corps, U. S. A., headquarters 78th Division, *Camp Dix, N. J.*
Larsen, Lester Reginald, second lieutenant, Engineer R. C., *Washington*.
Lavery, Geo. L., Jr., first lieutenant, Ordnance R. C., *Washington*.
Lay, Arthur J., captain, Aviation Section, Signal R. C., *Washington*.
LeFevre, Wm. G., lieutenant, Ordnance R. C., *Washington*.
Lewis, Charles B., captain, Ordnance R. C., Camp Lewis, *American Lake, Wash*.
Lewis, Harry R., Jr., first lieutenant, Ordnance R. C., Springfield Armory, *Springfield, Mass*.
Lipsner, B. B., captain, Air Division, Aviation Section, Signal R. C., *Washington*.
McIntyre, H. C., captain, Ordnance R. C., *Washington*.
McMurtry, Alden L., captain, office of Surgeon General, Sanitary Corps, U. S. N. A., *Washington*.
Mackie, Mitchell, major, Quartermaster Corps, U. S. A., A. E. F., *France*, assigned to Motor Truck Transport Section.
Marmon, Howard, major, Airplane Engineering Division, Signal R. C., McCook Field, *Dayton, Ohio*.
Marshall, W. C., captain, Ordnance R. C., *Washington*.
Martin, Kingsley G., captain, Quartermaster R. C., *Camp Dodge, Iowa*.
May, Henry, Jr., first lieutenant, Military Truck Production Section, Office of Quartermaster General, *Washington*.
May, O. J., captain, Aviation Section, Signal R. C., Camp Custer, *Battle Creek, Mich*.
Mergi, William, Co. B., First Battalion, 153d Depot Brigade, Camp Dix, *Wrightstown, N. J.*
Middleton, Ray T., first lieutenant, Air Service, A. E. F., *Paris, France*.
Miller, B. F., major, Quartermaster Corps, U. S. A., *Washington*.
Miller, C. A., first lieutenant, Quartermaster Corps, U. S. N. A., *Washington*.
Moffat, Alex. W., ensign, commanding U. S. S. "Tamarack" (S. P. 561), Naval Defense Reserve, Postmaster, Foreign Station, *New York*.
Moncrieff, V. I., captain, Aviation Section, Signal R. C., *Washington*.
Morgan, M. B., captain, Ordnance R. C., *Washington*.
Murphy, Joseph G., Sanitary Corps, U. S. N. A., *Washington*.
Myers, J. L., first lieutenant, Ordnance R. C., *Washington*.
Nahikian, S. M., lieutenant, Aviation School, Massachusetts Institute of Technology, Cambridge, Mass.
Oldfield, Lee W., captain, Signal R. C., *Washington*, assigned as aeronautical engineer.
Ommundson, H. P., Flying Corps, U. S. N., Aeronautic Station, *Pensacola, Fla*.
Otto, Henry S., lieutenant, Intelligence Section, A. E. F., *France*.
Pagé, Victor W., first lieutenant, Aviation Section, Signal R. C., *Mineola, N. Y.*
Paine, C. L., captain, Ordnance R. C., 318 North Illinois Avenue, *Indianapolis*, assigned to work on tanks.
Parker, Richard E., captain, Quartermaster R. C., *Washington*, assigned to Southern Department.
Pearmain, W. J., captain, Ordnance R. C., A. E. F., *France*.
Peifer Carl B., lieutenant, Specification Section, Signal Corps, U. S. A., *Washington*.
Pfeiffer, Ben. S., first lieutenant, Ordnance R. C., Rock Island Arsenal, *Rock Island, Ill.*, assigned to Motor Section.
Post, Edwin M., Jr., lieutenant, U. S. Air Service, A. E. F., *France*.
Potter, Austin E., lieutenant, New York Naval Militia, *Brooklyn, N. Y.*
Powell, W. B., officer in charge of transportation, Imperial Ministry of Munitions, (mail) Box 94, *Quebec, Can*.
Pullen, Daniel D., major, 7th Regiment, Engineer Corps, U. S. A., A. E. F., *France*.
Ranney, A. Elliot, major, Air Division, Signal Corps, U. S. A., *Washington*.
Rawley, Jos., captain, Co. A., 310th Engineers, U. S. A., Camp Custer, *Battle Creek, Mich*.
Robinson, H. A., ensign, N. R., U. S. N., *Washington*.
Rose, Charles B., major, Equipment Division, Signal Corps, U. S. A., *Washington*.
Rosenthal, Wm. C., private, U. S. N. A., 507 Nineteen Hundred Euclid Bldg., *Cleveland*.
Sandt, A. R., sergeant, Ordnance Department, U. S. A., Rock Island Arsenal, *Rock Island, Ill.*, assigned to Motor Section Instruction School.
Schoenfuss, F. H., captain, Ordnance R. C., *Washington*.
Schoepf, T. N., captain, Engineer R. C., *Washington*.
Selfridge, S. W., first lieutenant, Ordnance R. C., *Washington*.
Slade, Arthur J., captain, Aviation Section, Signal R. C., *Washington*.
Smith, Frank E., major, Signal Corps, U. S. A., *Washington*.
Smith, Mark A., first lieutenant, Marine Corps, U. S. N., *Washington*.
Sprague, G. A., Co. D., 310th Engineers, Camp Custer, *Battle Creek, Mich*.
Steinau, J. M., private, Sanitary Corps, U. S. N. A., *Washington*.
Strahlman, Otto E., first lieutenant, Aviation Section, Signal R. C., (mail) McCook Field, *Dayton, Ohio*.
Strauss, N. Frank, lieutenant, Ordnance R. C., *Washington*.
Swinton, D. R., first lieutenant, Quartermaster Corps, U. S. A., assigned to office of Quartermaster General.
Teetor, D. C., captain, Ordnance R. C., *Kenosha, Wis.*, assigned to Motor Section.
Thompson, H. E., first lieutenant, Motor Equipment Section, Carriage Division, Ordnance R. C., *Washington*.
Thomson, Clarke, lieutenant, Signal R. C., *Washington*.
Titsch, Walter H., captain, Quartermaster Corps, U. S. N. A., *Washington*.
Tolman, Edgar Bronson, Jr., first lieutenant, 311th Engineers, U. S. A., Camp Grant, *Rockford, Ill*.
Turner, Harry C., captain, Engineer R. C., A. E. F., *France*.
Twachtman, Quentin, first lieutenant, Engine Design Section, Signal R. C., *Washington*.
Underhill, C. R., captain, Radio Section, Signal R. C., *Washington*.
Vail, E. L., lieutenant, Signal Corps, U. S. A., *Washington*.
Vincent, Jesse G., lieutenant colonel, Aviation Section, Signal Corps, U. S. A., Miami Hotel, *Dayton, Ohio*.
Vonachen, F. J., lieutenant, Ordnance Department, U. S. N. A., Rock Island Arsenal, *Rock Island, Ill*.
Waldon, Sidney D., colonel, Equipment Division, Signal Corps, U. S. A., *Washington*.
Wall, William Guy, major, Ordnance R. C., *Washington*, assigned to motorization work.
Walter Maurice, first lieutenant, Ordnance R. C., *Washington*.
Walton, Frank, acting sergeant, Quartermaster Corps, U. S. A., Quartermaster Repair Unit, (mail) *Washington, D. C.*
Wetherill, S. P. Jr., major, Quartermaster R. C., *Washington*.
Whittenberger, Owen M., first lieutenant, Ordnance R. C., *Washington*, assigned to Office of Chief of Ordnance.
Wilson, T. S., lieutenant colonel, First Indiana Field Artillery, *Santa Fe, N. M.*
Wodehouse, B. A., sergeant, Co. A, 339th Infantry, *Camp Custer, Mich*.
Wood, Harold F., lieutenant, Specification Section, Equipment Division, Signal R. C., *Washington*.
Woods, S. H., captain, Military Truck Production Section, Office of Quartermaster General, *Washington*.

Civilian Honor Roll

Adams, Porter H., Office of the Section Commander, First Naval District, *Rockford, Me*.
Agins, Herman J., Quartermaster Engineering Department, War Department, *Washington*.
Anderson, E. S., mechanical engineer, Aviation Section, Signal Corps, U. S. A., Rockwell Field, N. Island, *San Diego, Cal*.
Bare, Erwin L., automobile body designer, Office of Quartermaster General, *Washington*.
Barnhardt, Geo. E., instructor, Signal Corps Aviation School, *San Diego, Cal*.
Belling, G. C. C., U. S. Navy Department, Custom House, *Boston*.
Booth, Fred C., draftsman, Motor Transport Division, Quartermaster Department, U. S. A., *Washington*.
Bourquin, J. F., supervisor of chassis assembly, Military Truck Production Section, Office of Quartermaster General, *Washington*.
Bradfield, E. S., Engineering Department, Naval Factory, *Philadelphia*.
Burton, W. Dean, aeronautical mechanical engineer, Signal Corps, U. S. A., *Fort Omaha, Neb*.
Caldwell, Frank W., aeronautical mechanical engineer, Aviation Section, Signal Corps, *Washington*, (mail) 1449 Massachusetts Avenue, N. W.
Chapman, Robert H., U. S. N., Spartanburg, S. C., assigned to Aeronautical Division.
Chauveau, Roger, aeronautical mechanical engineer, Aviation Section, Signal Corps, *Washington*.
Clark, Elmer J., Signal Corps, U. S. A., *Portland, Ore.*, assigned as district manager of inspection.
Coffin, Howard E., chairman, Aircraft Production Board, *Washington*.
Costello, John V., aeronautical engineer, airplane engineering division, Signal Corps, *Dayton, Ohio*.
DeKlyn, John H., technical assistant, National Advisory Committee on Aeronautics, *Washington*.
Dick, Robert I., motor truck expert, Ordnance Department, Camp Dodge, *Iowa*.
Diffin, F. G., chairman, International Aircraft Standards Board, *Washington*.
Edgerton, A. H., aeronautical mechanical engineer, Inspection Section, Signal Corps, U. S. A., assigned to Equipment Division.
Edmondson, D. E., U. S. Signal Service at Large, *Washington*, assigned as inspector of airplanes and airplane engines, Ericsson Mfg. Co., *Buffalo*.
Elliott, E. M., U. S. Public Service Reserve, Department of Labor, 1712 I Street, *Washington*.
Ericson, Friehof G., representative of Canada, International Aircraft Standards Board, *Washington*.
Ferry, Phillips B., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio*.
Fowler, Harlan D., aeronautical engineer, Aviation Section, Signal Corps, *Mineola, N. Y.*

Froesch, Charles, aeronautical mechanical engineer, Aviation Section, Signal Corps, *Washington.*
Gill, R. O., inspector of airplanes, Equipment Division, Signal Corps, (mail) Dayton-Wright Airplane Co., *Dayton, Ohio.*
Girl, Christian, director, Military Truck Production Section, Office of Quartermaster General, *Washington.*
Grimes, C. P., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio,* assigned to airplane engineering department.
Gorman, E. J. B., U. S. Flying Corps, N. R., U. S. N., *Dayton, Ohio,* assigned to inspection of airplane engines, Dayton-Wright Aeroplane Co.
Guernsey, Chas., Quartermaster Corps, U. S. A., *Washington,* assigned to Motor Transportation Board.
Gunn, E. G., production engineer, Quartermaster Corps, U. S. A., *Washington,* assigned to Motor Transportation Division.
Hale, W. A., aeronautical mechanical engineer, Signal Corps, U. S. A., *Dayton, Ohio.*
Hallett, Geo. E. A., aeronautical mechanical engineer, Signal Corps, Aviation School, *San Diego, Cal.*
Harrigan, F. P., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio;* assigned to Plane Design Section.
Heckel, C. E., truck designer, Transport Division, Quartermaster Corps, U. S. A., *Washington.*
Hicks, Harlie H., airplane engineering division, Signal Corps, U. S. A., *Dayton, Ohio.*
Hobbs, J. W., automobile expert, Ordnance Department, Rock Island Arsenal, *Rock Island, Ill.*
Holden, F. M., airplane engineering division, Signal Corps, U. S. A., *Washington.*
Honigman, Jos K., instructor, U. S. School of Military Aeronautics, Princeton University, *Princeton, N. J.*
Hoyt, F. R., Aviation Section, Signal Corps, *Washington.*
Kalb, Lewis P., assistant supervisor of inspection, Military Truck Production Section, office of Quartermaster General, *Washington.*
King, Charles B., aeronautical mechanical engineer, Aviation Section, Signal Corps, *Washington.*
Kishline, Floyd F., laboratory assistant, Quartermaster Corps, *Washington.*
Kroeger, F. C., Quartermaster Corps, U. S. A., *Washington,* assigned as engineer on electrical equipment.
Kuempel, Reuben, Emergency Fleet, U. S. N., *Pensacola, Fla.,* assigned as aeronautical draftsman, Hull Division, Department of Construction and Repair.
Laddon, I. M., aeronautical mechanical engineer, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*
Lane, Abbott A., inspector, Aviation Section, Signal Corps, (mail) Room 52, 870 Woodward Avenue, *Detroit.*
Leopold, Jos., Engineers' School, U. S. School of Military Aeronautics, Ohio State University, *Columbus, Ohio.*
Longletz, Wesley, Signal Corps, U. S. A., assigned as inspector on airplane engines at The Nordyke & Marmon Co., *Indianapolis.*
McCain, Geo. L., Signal Corps, U. S. A., *Dayton, Ohio,* assigned to airplane engineering department, Engine Design Section.
McMaster, Marcenus D., aeronautical engineer, Equipment Division, Signal Corps, *Washington.*
Mennen, F. E., Quartermaster Corps, U. S. A., *Washington,* assigned to Transportation Division.
Morgan, G. W., supervisor of plant survey, Military Truck Production Section, Office of Quartermaster General, *Washington.*
Nelson, A. L., aeronautical mechanical engineer, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*
Neumann, John W., Planning Section, Machine Division, U. S. Navy Yard, *Philadelphia.*
Norris, G. L., Inspection Section, Equipment Division, Signal Corps, *Washington.*
O'Malley, John M., instructor, Aviation School, Signal Corps, *Washington.*
Otis, J. Hawley, Ordnance Department, U. S. A., Camp Dodge, *Des Moines, Iowa.*
Parish, W. F., Signal Corps, U. S. A., *Washington,* assigned to Specification Section, Equipment Division.
Parker, Victor C., Signal Corps, U. S. A., *Washington,* assigned to Equipment Division.
Parris, Jr., Edward L., senior inspector, Aviation Section, Signal Corps, (mail) Ericsson Mfg. Co., *Buffalo.*
Perrin, J. G., assistant, Signal Corps, U. S. A., 401 Lindsey Bldg., *Dayton, Ohio,* assigned to airplane engineering division.
Proctor, C. D., Ordnance Department, U. S. A., Rock Island Arsenal, *Rock Island, Ill.,* assigned to Motor Section, Carriage Division.
Rice, Harvey M., inspector, Aviation Section, Signal Corps, (mail) Curtiss Aeroplane Co., *Buffalo.*
Riddle, E. C., U. S. School of Military Aeronautics, *Champaign, Ill.*
Rippingille, E. V., Aviation Section, Signal Corps, *Washington.*
Rogers, John M., aeronautical engineer, Bureau of Construction & Repair, Navy Department, *Washington.*
Ruckstell, G. E., Signal Corps, U. S. A., assigned as aeronautical mechanical engineer, *Detroit.*
Salisbury, Edward V., chief of motor transportation, American International Corp., Government Shipbuilding Yard, Hog Island, *Philadelphia.*
Schell, John A., aeronautical mechanical engineer, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*
Schupp, Arthur A., aeronautical mechanical engineer, Aviation Section, Signal Corps, *Washington.*
Serrell, Ernest, aeronautical mechanical engineer, Aviation Section, Signal Corps, *Washington.*
Shillinger, G. P., Ground Officers' Engineering School, Kelly Field No. 1, *San Antonio, Tex.,* assigned as instructor in ignition, starting and lighting.
Sloane, Jno. E., Signal Corps, U. S. A., *Washington,* assigned to Equipment Division.
Smith, G. W., Jr., aeronautical mechanical engineer in charge of experimental division, Engineering Department, Naval Aircraft Factory, U. S. Navy Yard, *Philadelphia.*
Stalb, Arthur R., Jr., U. S. Navy Aeronautic Station, *Pensacola, Fla.,* assigned as aeronautic draftsman, Hull Division.
Stanton, D. T., military instructor, U. S. Army School of Military Aeronautics, Cornell University, *Ithaca, N. Y.*
Stout, William B., technical advisor, International Aircraft Standards Board, *Washington.*
Thibault, F. J., aeronautical mechanical engineer, Signal Corps, U. S. A., *Washington.*
Tone, Fred I., inspector, Aviation Section, Signal Corps, *Washington.*
Tracy, Percy Wheeler, supervisor of parts plants, Military Truck Production Section, Office of Quartermaster General, *Washington.*
Utz, John G., supervisor of inspection, Office of Military Truck Production Section, Office of Quartermaster General, *Washington.*
Van Loon, Henry M., 310th Engineers, Camp Custer, *Battle Creek, Mich.*
Wade, Gustav, inspector, Aviation Section, Signal Corps, *Washington.*
Waldron, Russell E., Signal Corps, U. S. A., *Detroit,* assigned to Equipment Division.
Walker, Karl F., automotive engineer, Quartermaster Corps, U. S. A., *Washington,* assigned to Engineering Laboratory.
Walter, John M., mechanical draftsman, Bureau of Ordnance, Navy Department, *Washington.*
Warner, Edward P., Signal Service at Large, U. S. A., *Washington,* assigned as aeronautical engineer.
Waterhouse, W. J., aeronautical engineer, Aviation Section, Signal Corps, (mail) Dayton-Wright Airplane Co., *Dayton, Ohio.*
Weiss, E. A., automobile designer, Quartermaster Corps, U. S. A., *Washington,* (mail) 812 C Street, S. E.
Whinne, Wilbur H., inspector, Quartermaster Corps, U. S. A., *Detroit.*
White, Percival, automobile expert, Ordnance Department, U. S. A., Rock Island Arsenal, *Rock Island, Ill.*
Winter, E. A., War Department, Rock Island Arsenal, *Rock Island, Ill.*
Worthen, C. B., inspector, Aviation Section, Signal Corps, U. S. A., *Washington.*

Applications *for* Membership

A list of current applications for membership is given below. The members are urged to send any pertinent information with regard to those whose names are given which the Council should have for consideration prior to their election. It is requested that such communications from members should be sent promptly.

Camusat, Maurice, tool engineer, Automobiles Delage & Courbevoie, *Seine, France.*
Nielsen, Lauritz F., mechanical engineer, 2549 Fillmore St., *Minneapolis.*
Breeze, George Almond, carburetion engineer, Holley Kerosene Carbureter Co., *Detroit.*
Bushnell, Philip S., assistant engineer, The Standard Parts Co., *Cleveland.*
Kent, Bert M., patent counsel, The Standard Parts Co., *Cleveland.*
Knobloch, William H., engine superintendent, Cleveland Tractor Co., *Cleveland.*
Loeser, William G., assistant sales manager, The Moto-Meter Co., Inc., *Long Island City, N. Y.*
Noakes, William Edward, draftsman, engineering department, Quartermaster Corps, *Washington.*
Umbenhauer, Harry Colliston, secretary-treasurer, Falls Tire Company, *Chicago.*
Green, L. P., production manager, The Cleveland Knife & Forge Co., *Cleveland.*
Lambert, Harry E., automobile draftsman, Pan Motor Co., *St. Cloud, Minn.*
Martin, Charles H., president, general manager, Martin Rocking Fifth Wheel Co., *Springfield, Mass.*
Sasamoto, Lieut. Col. Kikutaro, Tokyo Military Arsenal, *Tokyo, Japan.*
White, Jr., Charles M., factory representative, Detroit Steel Products Co., *Detroit.*
Castle, Samuel Northrup, commercial engineer, General Electric Co., *New York.*
Wadsworth, Major George R., chief engineer, Signal Corps, U. S. A., Naval Aircraft Factory, Navy Yard, *Philadelphia.*
Bennett, Edwin O., mechanical and electrical engineer, National Advisory Committee for Aeronautics, *Washington.*
Bergenholtz, Niles G., assistant chief draftsman, Bijur Motor Lighting Co., Hoboken, N. J.
Broadwell, E. H., vice-president, The Fisk Rubber Co., *Chicopee Falls, Mass.*
Bubna, Richard C., draftsman, Quartermaster Corps, Motor Transport Division, *Washington.*
Bull, Ezra C., president, advisory engineer, Super-Lighting Co., Inc., *New York.*
Chase, Leon Wilson, professor of agricultural engineering, University of Nebraska, *Lincoln, Neb.*
Cook, Morris H., draftsman, Motor Transport Division, Quartermaster Corps, *Washington.*
Cox, Captain Abraham Beekman, consulting engineer, Ordnance Reserve Corps, *New York.*
Cutler, Wayne H., purchasing agent, Knox Motors Co., *Springfield, Mass.*

DONNELLY, JAMES M., charge of engineering department, Continental Motors Corp., *Muskegon, Mich.*
DOUGLAS, HARRY A., president, general manager, Douglas & Rudd Mfg. Co., *Bronson, Mich.*
DRESSER, L. W., mechanical engineer, Engineering Section, Motor Transportation Division, Quartermaster Corps, *Washington.*
GAMMETER, JOHN R., Rubber Manufacturing Engineer, The B. F. Goodrich Co., *Akron, Ohio.*
GIBBS, S. E., engineer, Moline Plow Co., *Moline, Ill.*
GLOVER, FRANK L., president, factory manager, Glover Equipment Co., *Indianapolis.*
GORDON, H. C., mechanic, Waterloo Gasoline Engine Co., *Waterloo, Iowa.*
GRAVEL, JOSEPH LUCIEN, draftsman, Engineering Section, Motor Transport Division, Quartermaster Corps, *Washington.*
GREENE, WILLARD C., optical and chemical engineer, Super-Lighting Co., Inc., *New York.*
HEATH, CHAUNCEY B., secretary, factory manager, Bantam Ball Bearing Co., *Bantam, Conn.*
HODGKINS, MERTON O., designing draftsman, Curtiss Engineering Corp., *Garden City, N. Y.*
JOHNSTON, W. S., president, W. S. Johnston, Inc., *Trenton, N. J.*
KLOER, CHARLES HUGO, designer, Duesenberg Motors Corp., *Elizabeth, N. J.*
KRAUSE, JR., ALBERT H., draftsman, Motor Transport, Quartermaster Corps, Engineering Division, *Washington.*
LONN, FIRST LIEUTENANT JULIUS MILLER, Ordnance Department, Frankford Arsenal, *Philadelphia.*
McDONALD, EUGENE GERNER, assistant chief engineer, Elgin Motor Car Corp., Argo, Ill.
MURDOCK, JULIAN HAZELTON, tool designer, Robert T. Pollock Co., *Boston.*
MURRAY, J. J., designer, Murray-Willat Co., *New York.*
NOGLE, BYRON S., automotive representative, Standard Oil Cloth Co., Inc., *New York.*
PICCIRILLI, LIEUTENANT PASQUALE J., Junior Grade, U. S. Navy Flying Corps, *Hammondsport, N. Y.*
RANDLES, GEORGE E., vice-president, The Foote-Burt Co., *Cleveland.*
REID, WILLIAM T., engineer, U. S. Naval Reserve, (mail) 82 Wilson St., *Brooklyn, N. Y.*
RICHARDSON, DONALD R., vice-president, general manager, Richardson Auto Electric Corp., *Baltimore, Md.*
ROGERS, J. D., Second Lieutenant, Motor Transport Section, Quartermaster Corps, U. S. N. A., *Washington.*
ROSE, LOUIS A., specialist, The Holt Manufacturing Co., *Peoria, Ill.*
SEWALL, EDWARD B., engineer, Gray Tractor Co., Inc., *Minneapolis.*
STEARNS, LELAND C., technical assistant, National Advisory Committee for Aeronautics, *Washington.*
SWEET, HAROLD B., assistant to manager, American Ever Ready Works, *Long Island City, N. Y.*
TARBOX, GURDON L., engineer, Standard Aero Corp., *Elizabeth, N. J.*
TARBOX, JOHN PRESTON, director of research department, Curtiss Engineering Co., *Garden City, N. Y.*
TOEPEL, MICHAEL E., service engineer, Splitdorf Electrical Co., *Newark, N. J.*
WEBER, HENRY E., checker, Nordyke & Marmon Co., *Indianapolis.*
WEST, GORDON, chief engineer, Swan Motor Corp., *Rockford, Ill.*

Applicants *Qualified*

The following list of applicants have qualified for admission to the Society between January 16 and February 15. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (Aff. Rep.) Affiliate Representative; (S. E.) Student Enrollment.

ALBION MOTOR CAR CO., LTD. (Aff. Mem.), *Scotstoun, Glasgow, Scotland.* Representatives: T. B. Murray, chairman, managing director and chief of technical department; N. O. Fulton, managing director, works department.
APPLETON, JOSEPH (Aff. Rep.) chief engineer, The Turner Mfg. Co., *Port Washington, Wis.*
ARMBRUST, C. R. (M) engineer, Hinkley Motors Corp., *Detroit,* (mail) 163 Willis West.
BLACK, ARCHIBALD (M) chief engineer, L. W. F. Engineering Co., *College Point, N. Y.,* (mail) 1069 E. 12th St., *Brooklyn, N. Y.*
BRITTEN, DANIEL L., captain, (A) Gun Division, Ordnance R. C., U. S. A., *Washington,* (mail) 278 York St., *Pottstown, Pa.*
BRAGG, CALEB S. (M) aviation research work, *Port Washington, N. Y.,* (mail) 31 W. 58th St., *New York.*
BROWN, WALTER (A) vice-president and general manager, The Webster Electric Co., *Racine, Wis.*
BUCKLEY, R. F. (J) chief draftsman, Premier Motor Corp., *Indianapolis,* (mail) 2222 N. Dearborn St.
BURKNESS, N. B. (M) chief engineer, Kleiber & Co., Inc., *San Francisco,* (mail) 1751 Market St.
CAMPBELL, E. EARL (S. E.) student, Purdue University, *W. Lafayette, Ind.* (mail) 1031 Hartford St., *Lafayette, Ind.*
CLARKE, THOMAS A. (A) production expert, Aviation Section, Signal Corps, U. S. A., 119 D. St. N. E., *Washington,* (mail) 1102 L St., N. W.
COCHRANE, FRED I. (A) general superintendent, Harvey E. Mack Co., 1229 Harmon Place, *Minneapolis.*
COFFIN, HOWARD A. (A) manager, Wheel Division, Detroit Pressed Steel Co., 1800 Mt. Elliott Ave., *Detroit.*
CONSOLIVER, E. L. (M) instructor in mechanical drawing and machine design, University of Wisconsin, *Madison, Wis.,* (mail) 415 N. Park St.
COOPER, G. S. (Aff. Rep.) McGraw Tire & Rubber Co., *E. Palestine, Ohio.*
CUCURELLO, JOHN J. (J) chief draftsman, G & O Mfg. Co., 598 State St., *New Haven, Conn.*
DODGE, HARRY DANIEL (A) sales manager, The Gray Tractor Co. Inc., *Minneapolis.*
DAWSON, FRANK (M) designing engineer, purchasing agent, factory manager, Master Trucks, Inc., 3132 Wabash Ave., *Chicago.*
DUFFY, GEO. N. (A) general superintendent, Canadian Aeroplanes, Ltd., *Toronto, Canada.*
DUTREUX, AUG. (M) managing director, Société Anonyme Pour l' Equipment Electrique des Vehicules, 26 Rue J-J. Rousseau, *Issy (Seine) France.*
DWYER, RAYMOND W. (J) engineer, Smith Wheel, Inc., 101 N. Geddes St., *Syracuse, N. Y.*
EK, G. A. (J) draftsman, tool designer, Minneapolis Steel & Machinery Co., *Minneapolis,* (mail) 2522 E. 24th St.
EMMERT, ARTHUR P. (M) assistant general superintendent, Warner Gear Co., *Muncie, Ind.*
FULTON, NORMAN OSBORNE (Aff. Rep.) managing director, works department, Albion Motor Car Co., Ltd., *Scotstoun, Glasgow, Scotland.*
GEMMER, G. A. (M) chief engineer, Day-Elder Motors Corp., *Newark, N. J.*
HASHIMOTO, KENSKE (M) aeronautical engineer, Parisano Aerial Navigation Co. of America, Inc., 220 W. 42nd St., *New York,* (mail) 601 W. 162nd St.
HEALD, H. P. (J) layout draftsman, Holt Mfg. Co., *Peoria, Ill.,* (mail) 517 Fourth Ave.
HELM, LOUIS P. (M) production manager, Olympian Motors Co., *Pontiac, Mich.*
HENDRICKSON, ROBT. T. (M) secretary-engineer, Hendrickson Motor Truck Co., 3538 S. Wabash Ave., *Chicago.*
HILL, H. D. (M) vice-president and chief engineer, Bates & Edmunds Motor Co., *Lansing, Mich.*
HOWERTH, HERBERT J. (J) assistant industrial engineer, Pierce-Arrow Motor Car Co., *Buffalo,* (mail) 980 Elmwood Ave.
JOHNSTON, EDWARD A. (M) manager, Experimental Department, International Harvester Co., 606 S. Michigan Ave., *Chicago.*
KANTERS, L. M. (M) assistant engineer, Waukesha Motor Co., *Waukesha, Wis.,* (mail) 323 West Ave.
KELSO, J. RUSSELL (A) owner, Kelso Mfg. Co., 58 Market St., *Trenton, N. J.,* (mail) 830 Riverside Ave.
KENT, RICHARD (J) draftsman, Holt Mfg. Co., *Peoria, Ill.,* (mail) 706 Cooper St.
KLECKNER, ARTHUR C. (A) chief engineer, The Webster Electric Co., *Racine, Wis.*
KRANICH, F. N. G. (M) agricultural engineer, Hyatt Roller Bearing Co., 1120 Michigan Ave., *Chicago,* (mail) 828 Foxdale Ave., *Winnetka, Ill.*
LAUTH, FRED P. (M) engineer, Sandow Motor Truck Co., 3333 W. Grand Ave., *Chicago,* (mail) 4917 Washington Blvd.
LARSEN, L. J. (Aff. Rep.) superintendent, The Turner Mfg. Co., *Port Washington, Wis.*
LUNEKE, LOUIS C. (M) assistant chief engineer, The Dayton-Wright Airplane Co., *Dayton, Ohio,* (mail) 57 Faulkner Ave.
LOEB, S. ARTHUR (A) secretary-treasurer, The Webster Electric Co., *Racine, Wis.*
McKONE, FRANK EDWARD (M) professor of aeronautics, University of Washington, *Seattle, Wash.*
McNALLY, JOHN E. (Aff. Rep.) Toro Motor Co., *St. Paul, Minn.*
McNAULL, M. W. (M) vice-president, purchasing agent, The McNaull Tire Co., *Toledo, Ohio.*
MILLER, GEO. B. (A) president, Waterloo Gas Engine Co., *Waterloo, Iowa.*
MILLER, ALBERT F. (J) mechanical engineer, Montgomery Ward & Co., *Chicago,* (mail) Field-Brundage Engine Works, *Jackson, Mich.*
MEDER, CHARLES (A) president and general manager, Witherbee Storage Battery Co., Inc., 1904 Broadway, *New York.*
MALTBY, F. D. (M) president, chief engineer, Maltby Auto Specialty Co., *Battle Creek, Mich.,* (mail) 363 W. Main St.
MORELAND, WATT L. (M) general manager, Moreland Motor Truck Co., 1701 N. Main St., *Los Angeles, Cal.*
MURRAY, T. BLACKWOOD (Aff. Rep.) chief of technical department, managing director, Albion Motor Car Co., Ltd., *Scotstoun, Glasgow, Scotland.*
PURCELL, BERNARD A., captain (A) commanding officer, Quartermaster R. C., 307th Supply Train, *Camp Gordon, Ga.*
ROGERS, RALPH F. (A) president, Rogers Mfg. Co., *Chicago.*
ROGERS, W. S. (M) chairman of executive board, consulting engineer, The Bantam Ball Bearing Co., *Bantam, Conn.*
RIDER, W. KEITH (J) designer, Wright-Martin Aircraft Corp., *Los Angeles, Cal.*
SEVALD, GEO. V. (A) salesman, The Steel Products Co., 2196 Clarkwood Road, *Cleveland.*
STARK, J. ROY (M) electrical engineer, Webster Electric Co., *Racine, Wis.*
STREETER, ROBT. L., major (M) In charge truck and tractor experimental work, Ordnance Department, U. S. A., Rock Island Arsenal, *Rock Island, Ill.*
TEGELER, G. (A) (Minn. Sec.) superintendent, Gray Tractor Co., *Minneapolis.*
TEMPLIN, ELLIS W. (M) assistant chief engineer, Selden Motor Vehicle Co., *Rochester, N. Y.*
THOMSON, MALCOLM (M) engineer, General Electric Co., *Lynn, Mass.,* (mail) 22 Monument Ave., *Swampscott, Mass.*
TUCKER, GORDON E. (A) road engineer, Zenith Carburetor Co., 245 W. 55th St., *New York,* (mail) Great Neck Station, N. Y.
TURNER MFG. CO., THE (Aff. Mem.) Port Washington, Wis. Representatives: L. M. Turner, vice-president, general manager; Joseph Appleton, chief engineer; L. J. Larson, superintendent.
TURNER, L. M. *Port Washington, Wis.*
VELGUTH, CARL (A) sales manager, production manager, John Obenberger Forge Co., *W. Allis, Wis.*
WOOD, L. D. (S. E.) student, Worcester Polytechnic Institute, *Worcester, Mass.,* (mail) 203 Golden Hill St., *Bridgeport, Conn.*